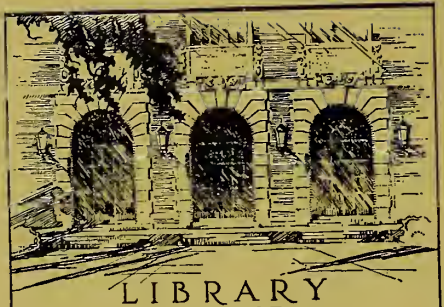

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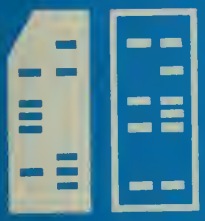

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DEPARTMENT OF COMPUTER SCIENCE · UNIVERSITY OF ILLINOIS · URBANA, ILLINOIS

QUARTERLY TECHNICAL PROGRESS REPORT

January, February, March 1965

Department of Computer Science
University of Illinois
Urbana, Illinois

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1. CIRCUIT RESEARCH PROGRAM

(Supported in part by the Office of Naval Research under Contract Nonr-1834(15).)

1.1 Summary

The work of the Task 15 Group was again divided into three major areas: The Paramatrix System (see section 1.2) with Michael Faiman, David Casasant and Edward Prozeller, the Electro-Optical work (see section 1.3) with Steven Whiteside and Dick Koo, and, finally the "Noise Computer" (see section 1.4) staffed by Chushin Afuso.

The Paramatrix System, which was described in the last Quarterly Progress Report, is now being built. With the exception of the dc-coupled voltage amplifier, all of the circuits needed in the system have been finalized. The details are given below.

The Electro-Optical work is in good straits, both theoretically and experimentally. It is to be noted that a level-lost version of the modulator system is being designed.

The "Noise Computer" has led to the design of a random pulse generator with a modifiable average frequency. Some theoretical work on testing for randomness has also been done.

1.2 Paramatrix Circuits

The circuits that have been designed for the Paramatrix System can be divided into three groups according to whether they operate with digital, analog, or hybrid (analog/digital) signals. In the material to follow circuits will be discussed according to the above classifications.

1.2.1 Digital Circuits

1.2.1.1 Variable-Frequency Clock

Since the speed of the Paramatrix System as a whole has not been determined precisely, a clock was designed with an adjustable frequency range of 100 kc to 1 mc. In addition the time symmetry of the output waveshapes

can be adjusted from an ON/OFF ratio of 1 to 10. The clock circuit shown in Fig. 1 is composed of standard circuits and little elaboration is necessary. The strobe output is the clock output after it is inverted and delayed 6 μsec, and it is used to strobe the logic circuitry which generate the matrix-scanning signals. This procedure guards against the possibility of race conditions in the control logic.

1.2.1.2 Matrix Flipflop

The flipflop which has been designed for driving the indicating lamps is a single loop regenerative circuit (Fig. 2). The two stable states are: both transistors on (lamp on) or both transistors off (lamp off). Thus the circuit draws negligible power in the off state, which is a very desirable feature since over 1,000 of these circuits are used. When the flipflop is off, Y_1 and/or Y_2 is at 0 volts and T_1 is reversed biased (the emitter of T_1 is at ~ - 2v). The circuit is turned on when both Y_1 and Y_2 are pulled down below -3.6 volts and because of the heavy regeneration that occurs in T_1 and T_2, the circuit will remain on even after Y_1 and Y_2 return to ground. In order to turn off the flipflop easily, it is necessary to cut off the emitter current in in T_1. This is done by using a current-driver circuit which is described below.

1.2.1.3 Flipflop Driver

The driver circuit is shown in Fig. 3

When X is 0 volts, T_2 is reverse biased and the 8 flipflops which are fed by T_2 are turned off. When X is -5 volts T_2 conducts and the connected flipflops can then be turned on by pulling down on inputs Y_1 and Y_2 in Fig. 2. Since it was desired to turn off one column of the matrix (32 flipflops) with the same X signal, the actual driver which is used in the system consists of the above topology with three additional transistors in parallel with T_2. The collector of each additional transistor controls 8 flipflops.

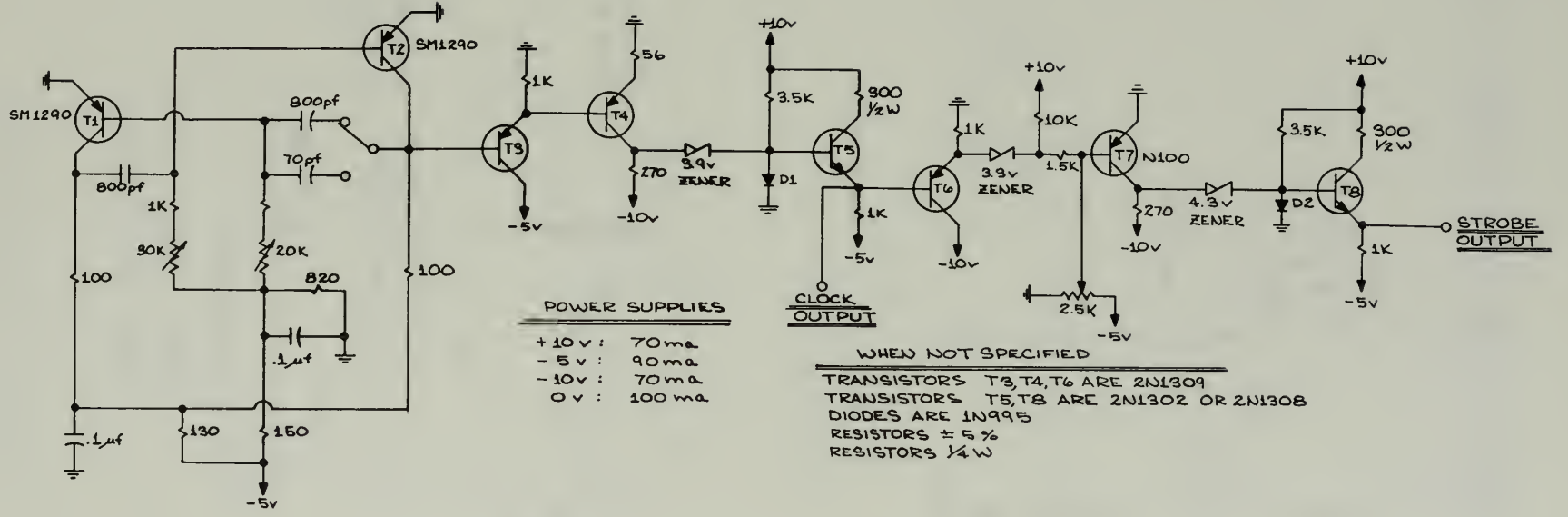

Figure 1. 100 kc--1 mc Clock

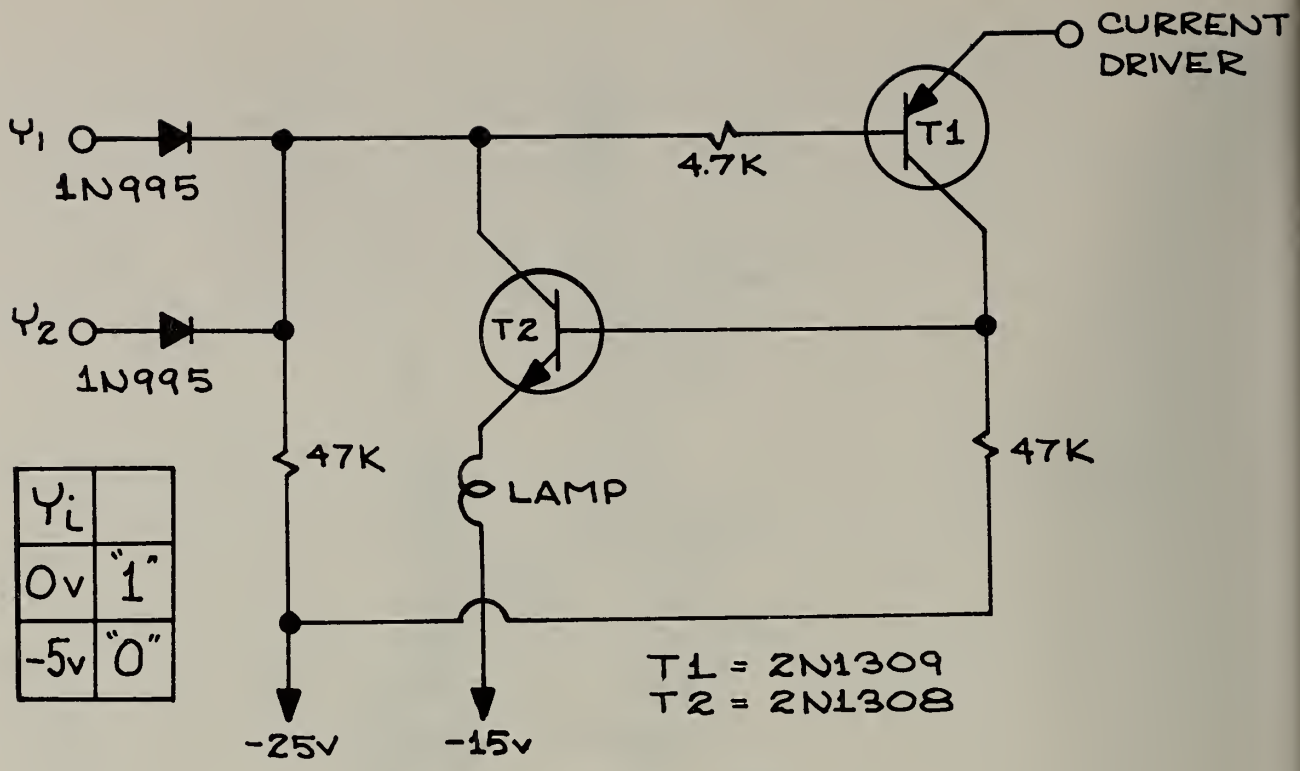

Figure 2. Flipflop Circuit

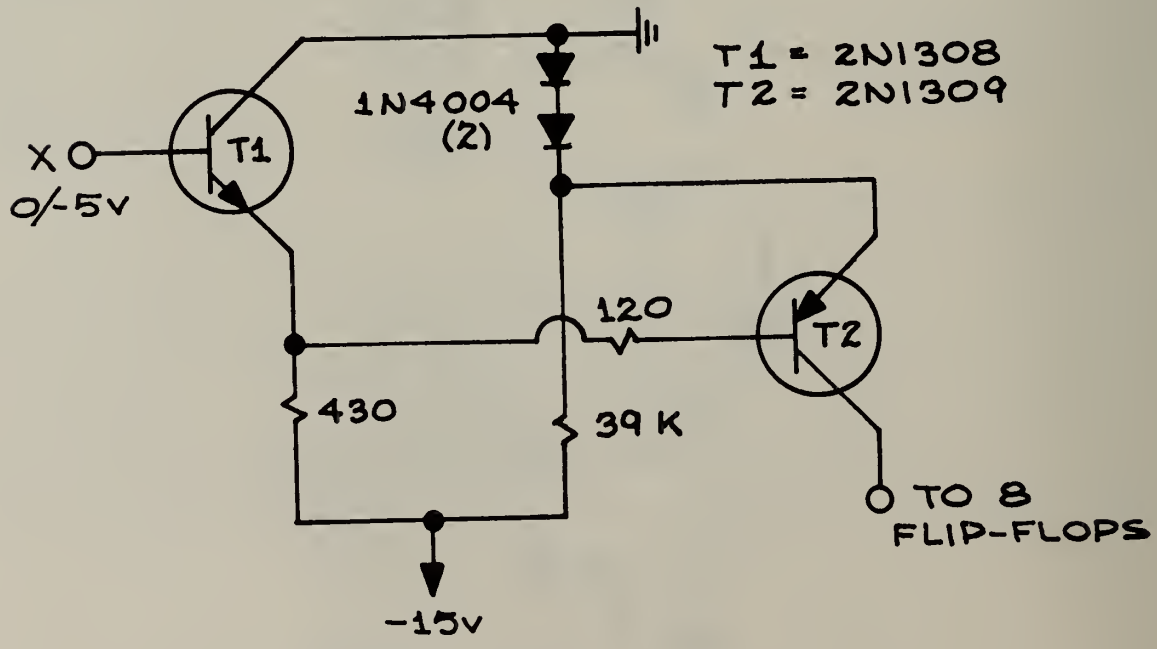

Figure 3. Flipflop Driver

1.2.2 Hybrid Circuits

The most novel of the Paramatrix circuits are the hybrid circuits in which analog information is controlled by digital pulses.

1.2.2.1 Diamond Gate

One of the first hybrid circuit requirements was for a device capable of transferring an analog signal from one point to another upon application of a digital control pulse. The ordinary transistor switch was not usable in this application because of the large offset voltage. The compensated circuit of Fig. 7 could not be controlled easily by a digital pulse and so it was decided to design a compensated diode switching circuit. (Fig. 4).

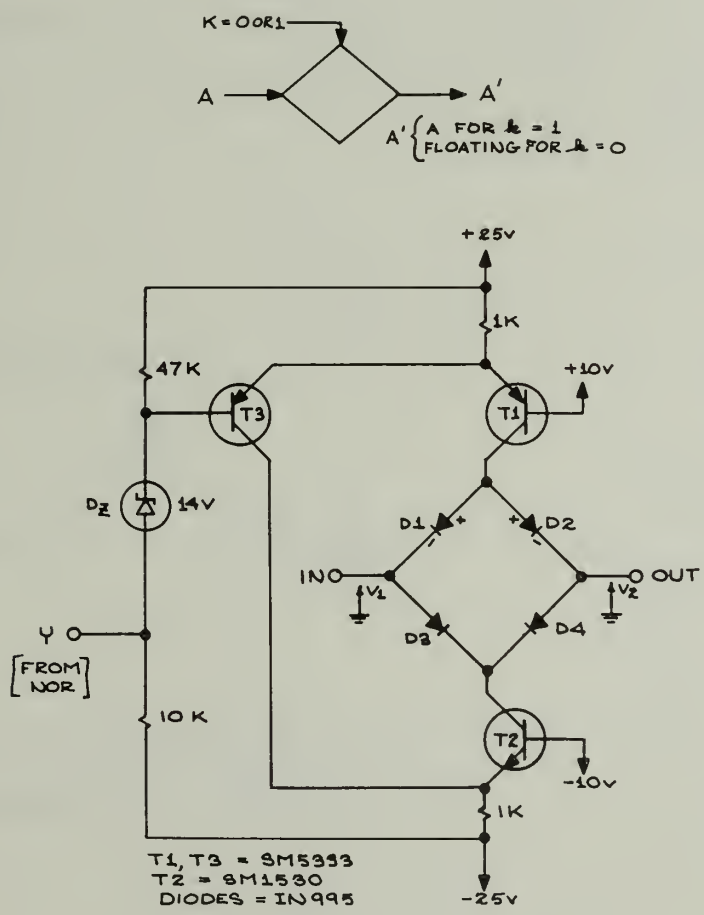

Figure 4. Diamond Gate

The principle of the diamond gate is to bias all four of the bridge diodes well into conduction with constant-current sources composed of T_1 and T_2. Thus with 0 volt signal and matched diodes, $V_1 = V_2$. As the input swings positive, V_2 increases and V_1 decreases and the drop across the gate is $\Delta V_1 + \Delta V_2 = \Delta V_s$. However if the nominal bias current is much larger than the maximum signal current, the bridge offset ΔV_s will be very small. An accuracy of $\frac{\Delta V_s}{V} < 1$ per cent has been easily achieved in the laboratory.

To switch the diamond gate it is necessary to remove the bias current from the bridge diodes. This is accomplished by T_3 and D_z. When Y = 0 volts T_3 is cutoff, the bridge is biased, and IN = OUT. When Y = - 5 volts T_3 is on, T_1 and T_2 are cutoff and the bridge looks like an open circuit.

Of course the diamond gate is a passive circuit and therefore all of its output current must be supplied at the input. There are some situations in the Paramatrix System where an active gate with current gain is desirable. This is accomplished by using an I-amplifier (discussed in section 1.2.3.1) together with the diamond and connecting the feedback path as shown in Fig. 5. By means of this connection it is possible to compensate for the added diamond gate offset voltage.

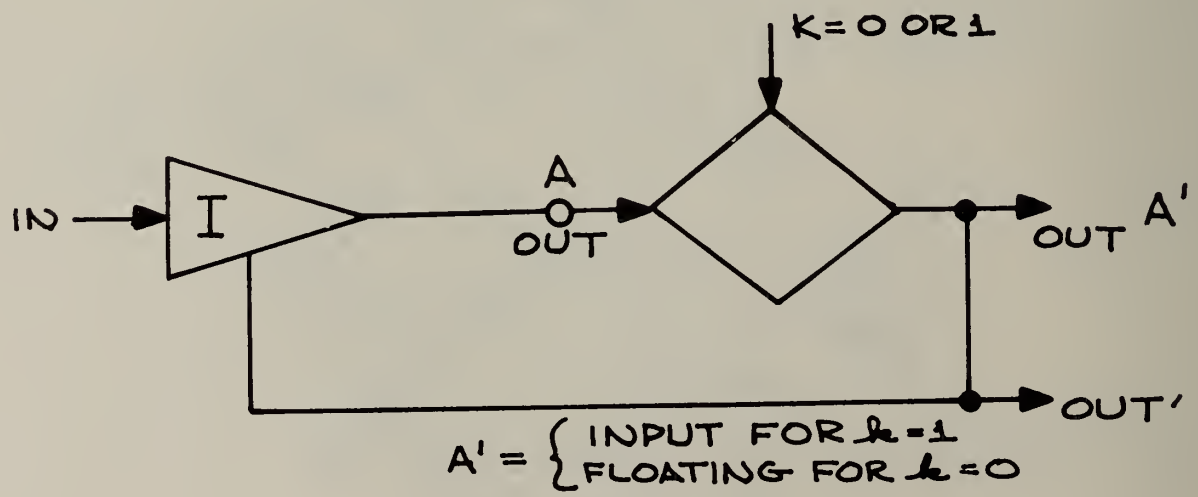

Figure 5. Active Gate

1.2.2.2 Comparator

The last hybrid circuit required was a precision analog comparator with an adjustable sensitivity. A number of possible topologies were tried but the circuit shown in Fig. 6 was finally adopted because of its elegant method of sensitivity control.

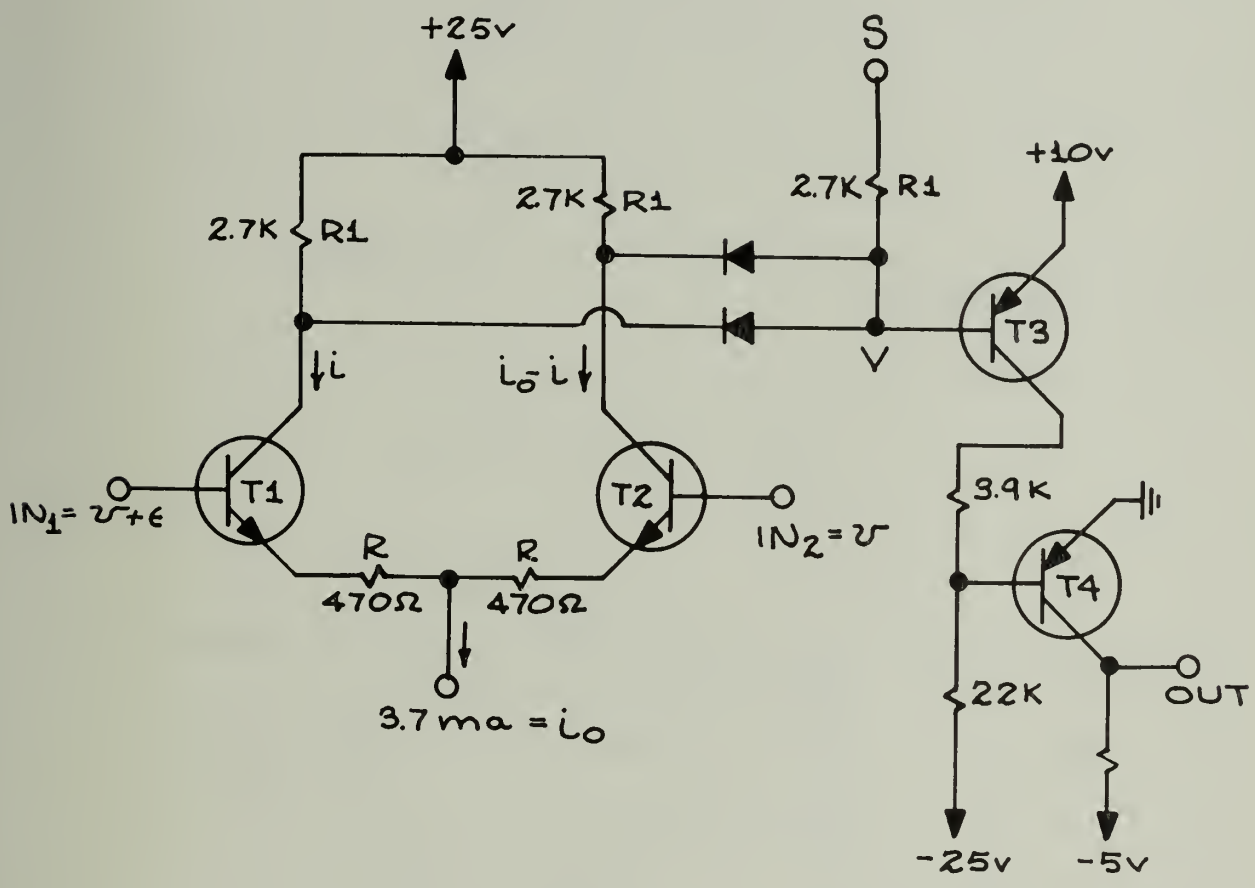

Figure 6. Comparator Circuit

An analysis of this circuit can be made as follows: let $IN_1 = v + \epsilon$, $IN_2 = v$; then, assuming $\alpha_{T_1} = \alpha_{T_2} = 1$ and all emitter base drops negligible, we have

$$v + \epsilon - iR = v - (i_0 - i)R, \quad i = \frac{i_0R+\epsilon}{2R}$$

and since $i \leq i_0$, $\epsilon_{max} = i_0R$ = maximum input difference for which circuit can indicate coincidence. Now assuming both diodes ideal, upper diode on

$$\frac{25-V}{R_1} + \frac{S-V}{R_1} = i = \frac{Ri_0+\epsilon}{2R}$$

or

$$V = 12.5 + \frac{1}{2}S - \frac{R_1(Ri_0+\epsilon)}{4R}$$

taking V = 10 volts as the threshold, i.e., V < 10 = COINCIDENCE, V > 10 volt = NONCOINCIDENCE.

We can derive conditions on the circuit values such that at

$$S = 10 \text{ volts} \quad \epsilon = \epsilon_{min} = 0 \text{ volts}$$

and at

$$S = 25 \text{ volts} \quad \epsilon = \epsilon_{max} = i_0R \text{ volts}$$

For this circuit the sensitivity can be set anywhere between

$$\epsilon = 0.1 \text{ volt}$$

and

$$\epsilon = 2.0 \text{ volt}$$

depending upon the value of S.

Transistors T_3 and T_4 in the output are used to make the output signal of the comparator compatible with conventional NOR logic.

1.2.3 Analog Circuits

Since the information signals in the Paramatrix System are analog in nature very precise current and voltage amplifiers are required in the processing of information.

1.2.3.1 Current-Amplifier

The ideal current amplifier for Paramatrix would have infinite current gain with zero offset voltage. A conventional emitter follower gives a current gain $\simeq \beta$ and a voltage offset equal to the emitter-base junction drop. A current gain of β is satisfactory; however the emitter-base junction drop is far too large an offset for paramatrix applications and hence it was necessary to design a compensated circuit. The design which resulted is shown in Fig. 7.

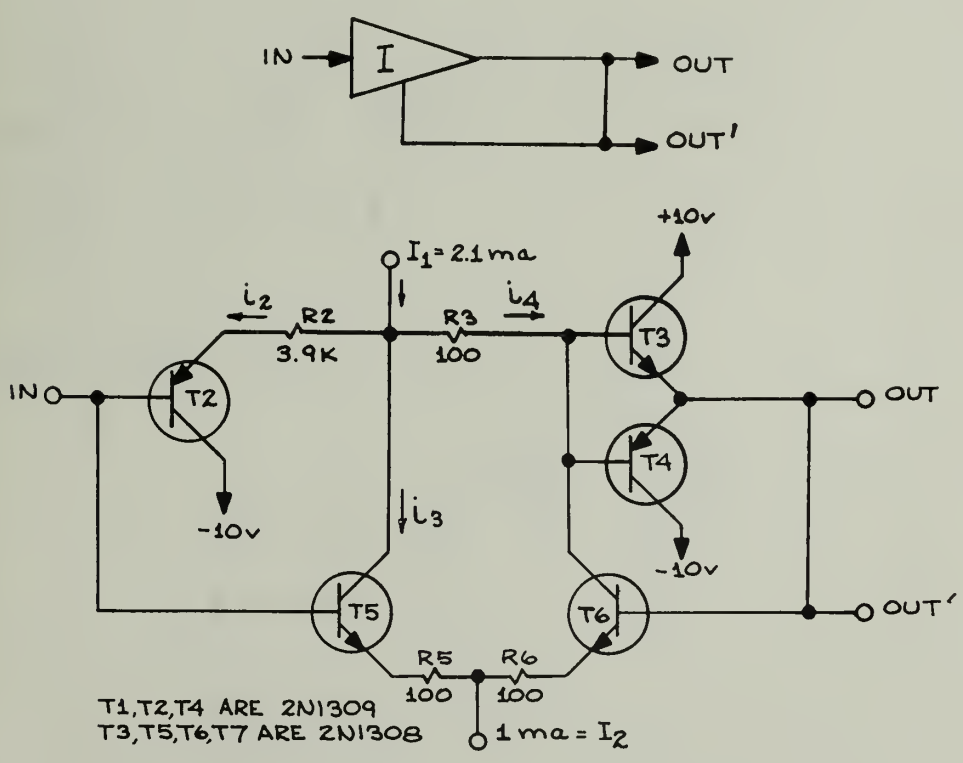

Figure 7. I--Amplifier

With good approximation the emitter current in T_2 is constant and hence the junction drop in T_2 is constant. It is then only necessary to compensate for the difference in junction drops in T_2 and T_3 or T_4 (whichever is conducting) as the input varies over its prescribed range. This difference detection is accomplish accomplished by using the switching amplifier composed of T_3 and T_4 which compares the input and output and adjusts the voltage drop i_4R_3 to compensate for any difference that may exist.

1.2.3.2 Voltage-Amplifier

The purpose of this circuit is to form Av_i from v_i, where v_i can assume values from $-.5 \leq v_i \leq +.5$. A is to be ≈ 16 such that $-8 \leq Av_i \leq +8$. The accuracy of this amplifier is to be approximately 1 per cent. The input impedance is to high and the output is to be capable of switching approximately 1 ma. The circuit is to operate at 1 mc frequencies.

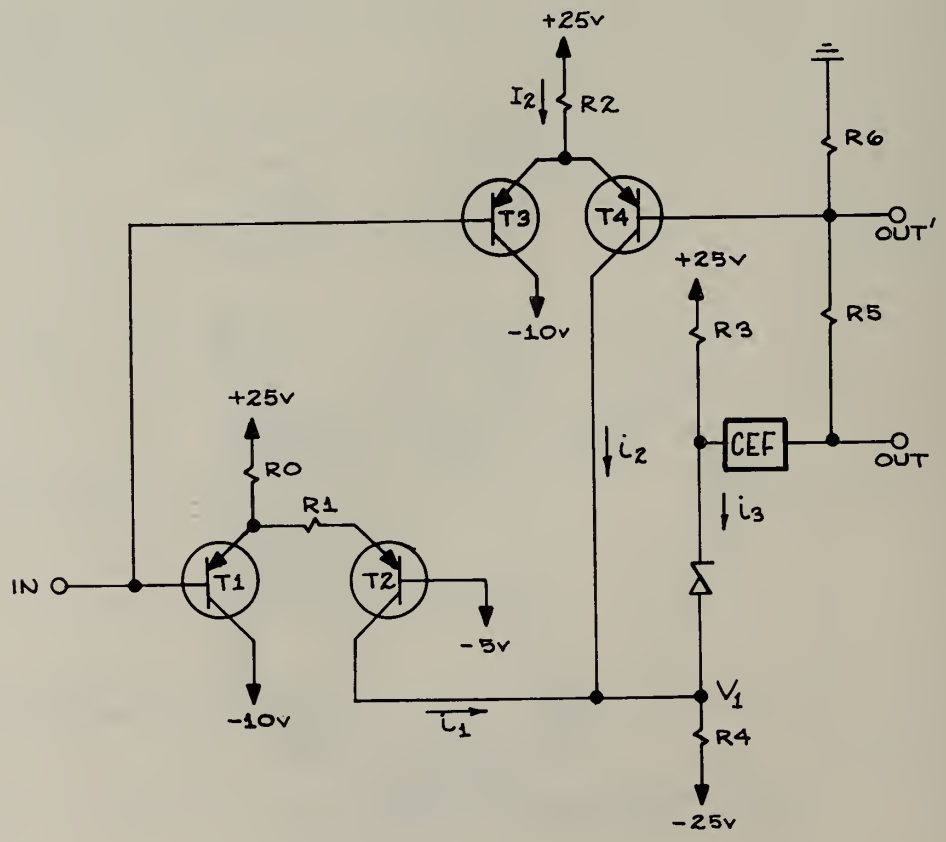

Figure 8. Difference-Amplifier Feedback

Test Circuit No. 1: Difference-Amplifier With Feedback

The gain of the circuit is given by $\frac{R_5 + R_6}{R_6}$. V'_{out} is compared with V_{in} by means of a difference amplifier (T_3, T_4). If V'_{out} is $> V_{in}$ then T_3 passes more current and T_4 passes less current. The current i_2 then decreases, V_1 decreases, V_2 decreases, V_{out} decreases, and V'_{out} decreases. Eventually $V'_{out} = V'_{in}$ at which time $i_2 = \frac{1}{2} I_2$. Similarly if $V'_{out} = V_{in}$, T_3 does not conduct and T_4 passes most of the current I_2. In this case V is raised, V_2 is raised, V_{out} is raised, and V'_{out} is raised. As before $V'_{out} = V_{in}$ finally.

The box labeled CEF in Fig. 8 is a compensated emitter follower. This is essentially a current amplifier with unity voltage gain over the range $-8 \leq V_2 \leq +8$. The error in this CEF is only about 30 mv: it is described as "Current Amplifier" above in 1.2.3.1.

The equations governing the performance of the circuit are (assuming $V_{eb} \approx 0$, $\alpha = 1$, and that the CEF draws 0 current).

$$i_1 = \frac{V_{in}+5}{R_1}, \quad i_2 = \frac{25-V_{in}}{R_2}, \quad i_3 = \frac{25-4v}{R_3}$$

$$V_1 = \frac{V_{in}+5}{R_1} + \frac{25-V_{in}}{R_2} + \frac{25-4v}{R_3} \quad R_4 = V_2 + V_z = V_{out} + V_z = 4V_{in} + V_z$$

Assuming our goal is a gain of 4 such that $V_{out} = 4V_{in}$

$$-\frac{V_{in}}{R_1} + \frac{V_{in}}{2R_2} + \frac{4V_{in}}{R_3} + \frac{4V_{in}}{R_4} = \frac{5}{R_1} + \frac{25}{2R_2} + \frac{25}{R_3} - \frac{V_z}{R_4}$$

let

$$\frac{1}{R_1} = a, \quad \frac{1}{2R_2} = b, \quad \frac{1}{R_3} = c, \quad \frac{1}{R_4} = d$$

for

$$V_{in} = 0 \quad -a + b + 4c + 4d = 0 \qquad d = \frac{1}{4}(a - b - 4c)$$

$$V_{in} = 0 \quad 5a + 25b + 25c - V_z d = 0 \qquad d = \frac{5}{V_z}(a + 5b + 5c)$$

$$\frac{1}{4}(a - b - 4c) = \frac{5}{V_z}(a + 5b + 5c)$$

$$0 = \left(\frac{5}{V_z} - \frac{1}{4}\right) a + \left(\frac{25}{11} + \frac{1}{4}\right) b + \left(\frac{25}{11} + 1\right) c \qquad (1)$$

All coefficients are > 0 unless $\frac{1}{4} > \frac{5}{V_z} \Longrightarrow V_z > 20$; $-8 \leq V_2 \leq 8$ for a gain of 4; $-2 \leq V_{in} \leq +2$, $-8 \leq V_{out} \leq +8$, $-30 \leq V_1 \leq -14$ for a choice of $V_z = 22$. This choice of values will make $V_{CB} > 25$ for T_2 and T_4, and also requires a very small value for R_1 in order that Equation (1) be satisfied. This produces a very large i_1 and power dissipation problems. High heating effects, however, lead to big thermal drift: the amplifier drifts by more than 11 mv after a complete $-8v \rightarrow 0 \rightarrow +8v$ output cycle. One possible solution would be to return R_4 to -50 volts instead of -25 volts. Due to the system this circuit is used in, it is not very advisable to have a supply voltage of 50 volts.

Test Circuit No. 2: Modified Gain 4 Difference Amplifier With Feedback

Certain modifications can be made in Test Circuit No. 1 to avoid the use of a 50 volt supply voltage. Current I_2 is derived from a constant transistorized current source. The input circuit is modified also. The CEF is replaced by a single emitter follower and the V_{eb} loss and variation is compensated for in the feedback circuit.

The feedback circuit has been modified slightly by inserting resistors in the emitters according to Fig. 9.

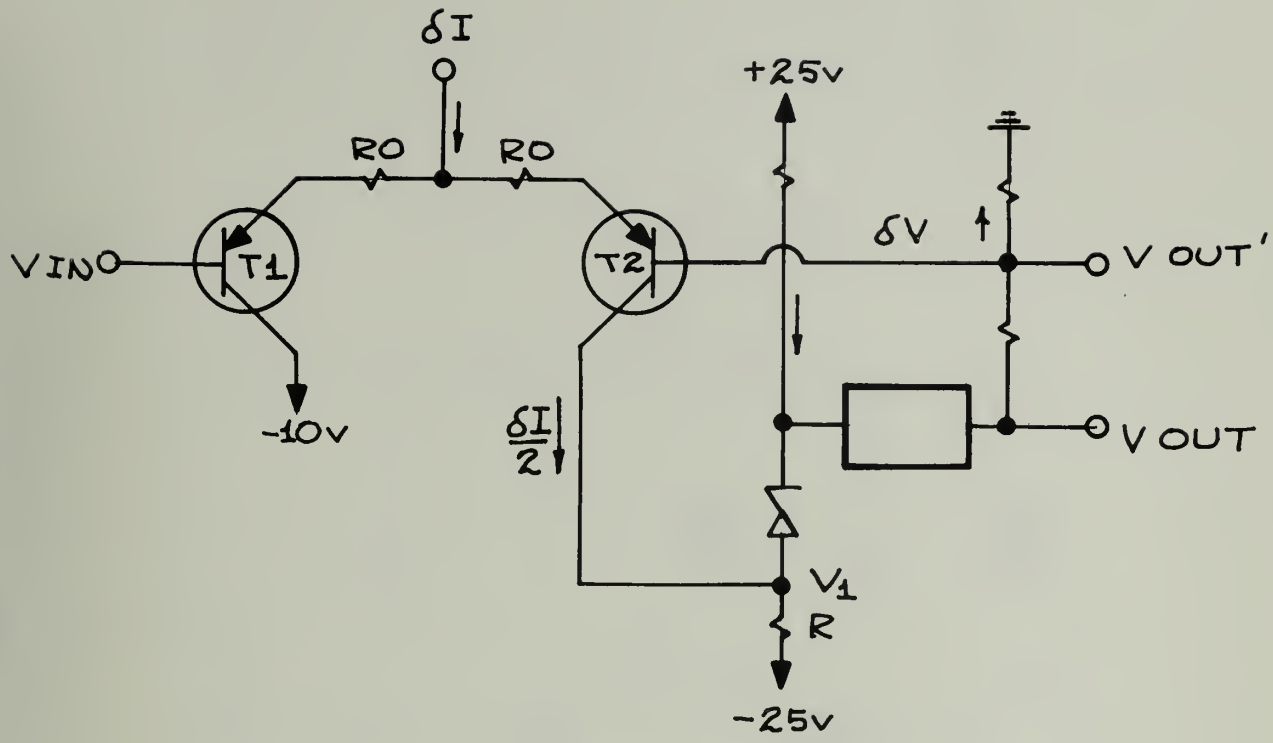

Figure 9. Modified Difference-Amplifier

If V'_{out} increases (or decreases) by δV we want to insure that V_1 also increases (or decreases) by 4 δv. If V'_{out} increases by δV the current increases by δI such that $\delta I R_0 = \delta V$, $\frac{\delta I}{2}$ is the increase in i_2. This increases V_1 by δIR and

$$\frac{1}{2}\,\delta IR = 4\delta V$$

$$\frac{\delta I}{8}\,R = \delta IR_0$$

hence

$$R_0 = \frac{1}{8}\,R.$$

This should provide better accuracy in the difference amplifier. The modified gain 4 amplifier is shown below.

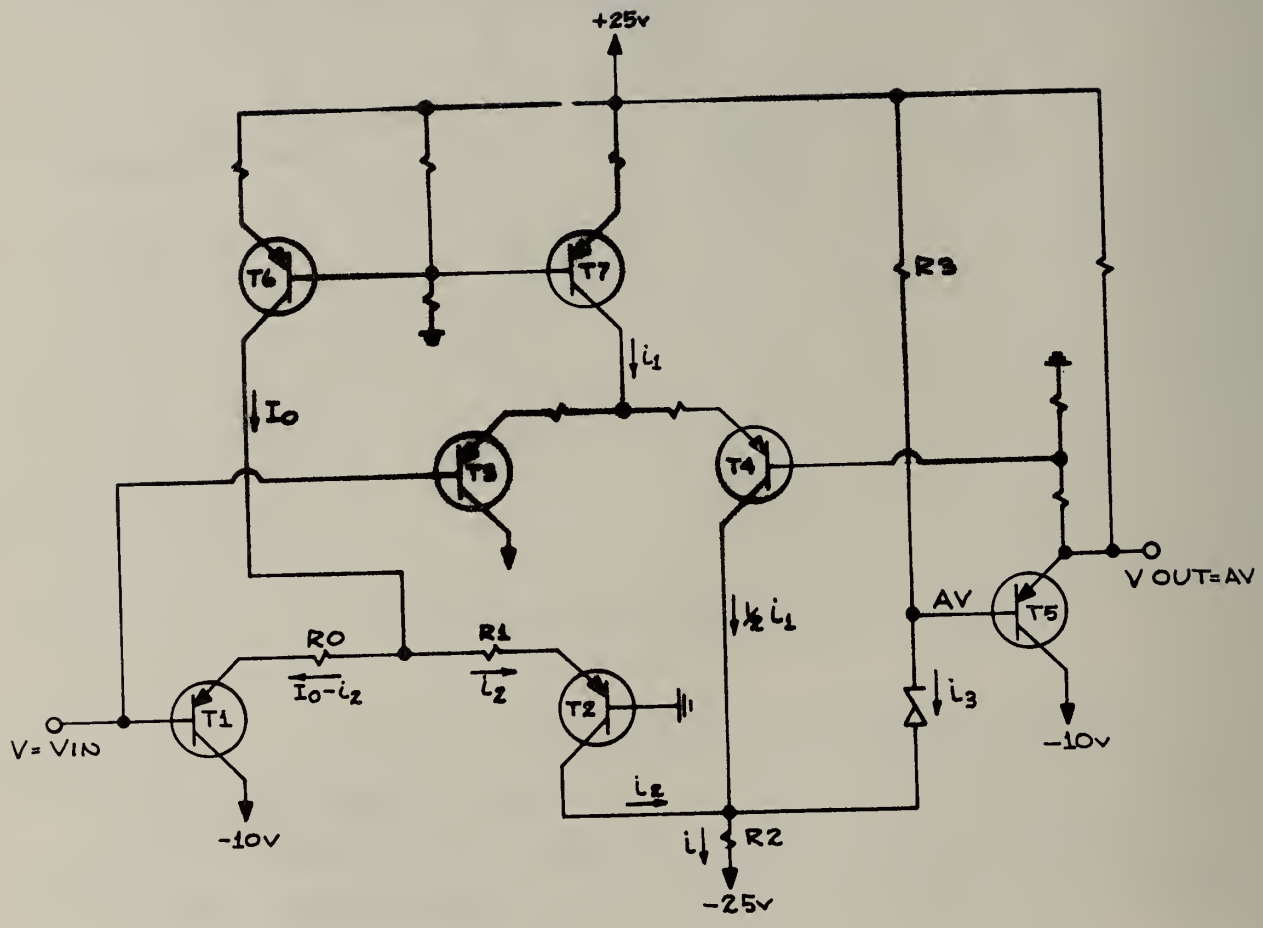

Figure 10. Modified Difference-Amplifier With Feedback

Assuming all $V_{eb} = 0.2v$ and $\alpha = 1$, the equations governing the circuit are

$$i_3 = \frac{25 - AV + 0.2}{R_3}, \quad \frac{di_3}{dv} = \frac{-A}{R_3}$$

$$i_2 = \frac{V + R_0 I_0}{R_0 + R_1}, \quad \frac{di_2}{dV} = \frac{1}{R_0 + R_1}$$

$$i_3 = \frac{1}{2} I_1 = \text{constant}$$

The gain is thus

$$\frac{di_3}{\partial v} + \frac{di_2}{\partial v} = \frac{R_2}{R_0 + R_1} - \frac{AR_2}{R_3} = \frac{R_2 R_3}{R_2 + R_3} \cdot \frac{1}{R_0 + R_1} = A$$

Let $R_0 = R_1$ since there is no advantage in making them different.

Let

$$I_0 = 6 \text{ ma}, \; R_1 = R_0 = .38k, \; R_3 = 47k, \; R_2 = 3.25k, \; V_z = 9.1v, \; I_1 = 2.5 \text{ ma}$$

Certain conditions must be satisfied for proper bias and operation.

a)	$AV - 0.2 - V_z \leq -2$	To properly bias T_2
b)	$i_2 > .25$ ma	To keep T_2 on
c)	$I_0 - i_2 > .25$ ma	or from 2) and 3), $I_0 - .25 > i_z > .25$
d)	$i_3 > .3$ ma	To trigger the zener
e)	$-8 \leq V_{out} \leq +8$	

The drift of the circuit appeared still to be > 50 mv after a complete cycle.

Test Circuit 3: Higher Gain Versions of the Modified Difference-Amplifier-Feedback System

The circuit of Fig. 10 was modified appropriately such that the gain was 16 (see Fig. 11).

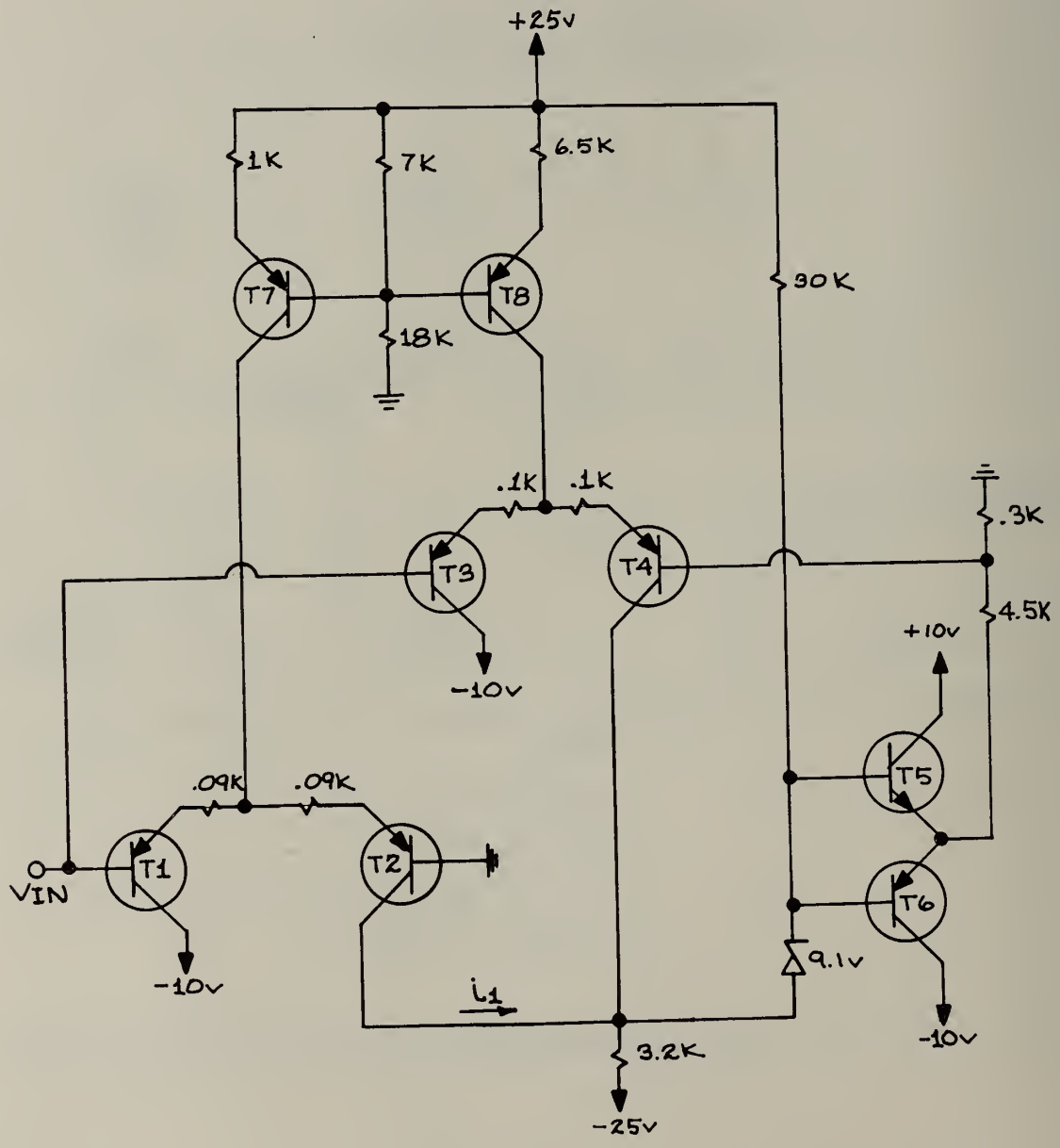

Figure 11. Gain 16 Versions of Amplifier of Fig. 3

At this point a digital voltmeter with an accuracy of 1 mv was used to measure V_{in} versus V_{out}. With this voltmeter any variations in V_{out} would appear to 4 places. The results showed that the readings of V_{out} were not stable. They drifted by as much as 100 mv.

The output circuit of T_5 and T_6 was used to enable the output to drive any kind of load easily. It was obvious that this drifting was a thermal effect. At first it was thought that the fact that T_5 was on only when $V_{in} > 0$ and T_6 was on only when $V_{in} < 0$ and thus the transistor in switching from off to on heated up its junction and thus the drift was produced. The output circuit of Fig. 11 was replaced by that of Fig. 10. The drift was still observed. The drift was actually due to the fact that i_2 varied from .75 ma to 6.25 ma. This variation in emitter current caused the temperature of the junction to increase and as I increased, this would increase T and this would make the drift appreciable even for a small change in i_e. The drift would be such as to decrease V_{out}. This was the observed result. Similarly when I was decreased, V_{out} increased due to drifting.

Test Circuit 4: Current Sink Version of Test Circuits

The circuit was then modified to keep all emitter currents within $\approx$ 0.5 ma of some average value. The bias on all transistor current source bases was modified and the power dissipation of all transistors was kept well below one-half rated value. The 2 transistors T_3 and T_4 in Fig. 11 were changed to Darlington connections to decrease the base current flowing in the output resistor stepdown arrangement. The resistor supplying current to the zener diode was replaced by a transistorized constant current source to ensure that the current through the zener diode was constant and thus the zener voltage was always the same. To do this it was necessary to insert a current sink. The circuit is shown in Fig. 12.

The results were somewhat improved. The drift in each reading was no more than 9 mv, the offset at $V_{in} = 0$ was $\approx$ 50 mv. Each reading was repeatable within $\approx$ 30 mv. The worst possible drift occurred naturally when V_{in} was switched from +.5 to -.5 volt. This meant that the output voltage changed by approximately

16 volts. All currents and voltages and transistor junctions in the circuit underwent their greatest change. The drift was then ≈ 110 mv. Various ideas were tried but this appeared to be the maximum accuracy of the circuit with such a topology. The 4 transistors in the output must be chosen such that their V_{eb} drops are the same within a few millivolts in order to insure accurate use of the feedback. The circuit does operate at over 1.2 mc.

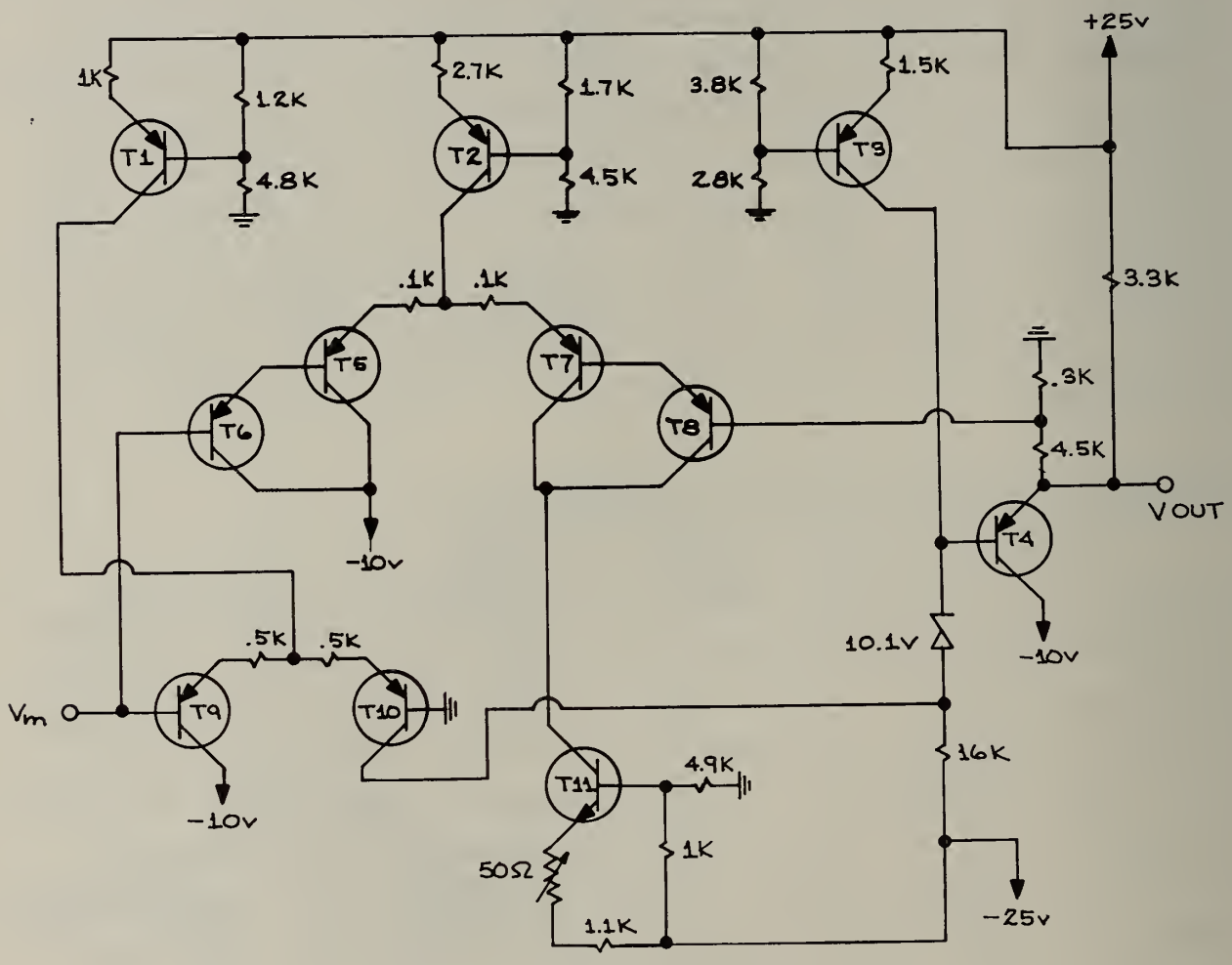

Figure 12. Current Sink Version

Test Circuit 5: NPN-PNP Topology

A new topology was now investigated as shown in Fig. 13.

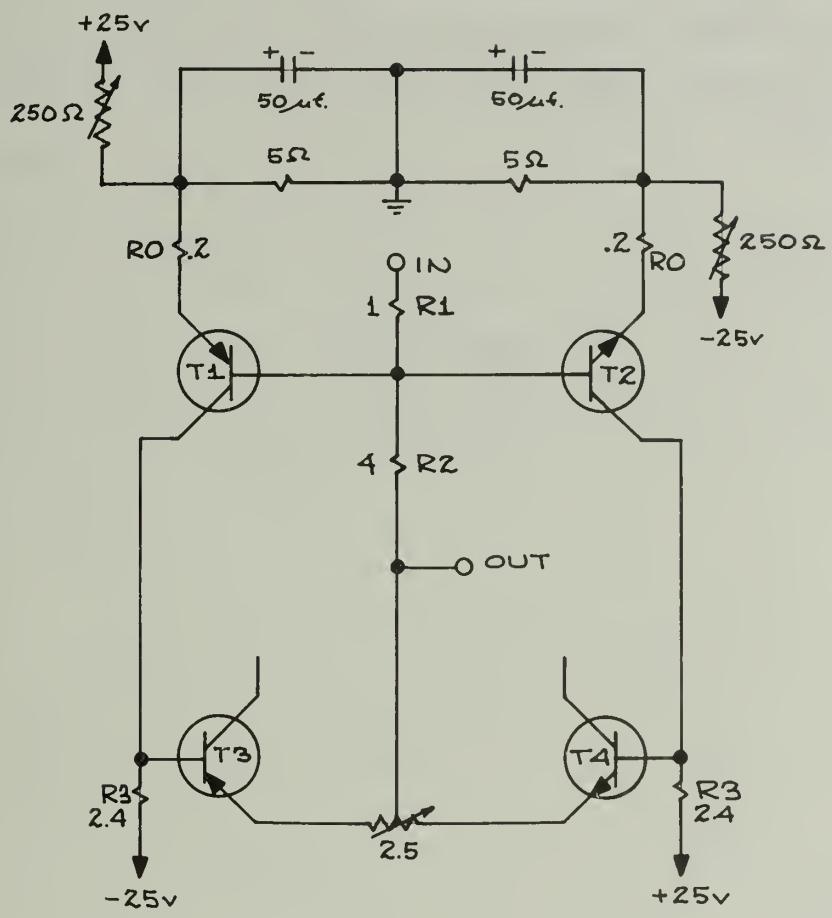

Figure 13. NPN-PNP Topology

The gain without feedback is $\gamma = \frac{R_3}{R_0}$. The gain with the feedback is

$$A = \frac{-\gamma}{1 + (\gamma+1)\frac{R_1}{R_2}}$$

for the circuit values given A ~ 2.3.

There is no drift, and no offset > 3 mv. The gain is approximately constant. The only problems are:

a) The circuit has 3 pots to adjust to fix $V_{in} = 0$, $V_{out} = 0$. This is a long process.

b) The input impedance is rather low ~ 1 K.

c) The output impedance is too high ~ 1.25 K.

d) The gain is much too low and 2 stages must be cascaded since the gain is negative.

e) The drift may become multiplied by the gain of the second stage.

Stabistors have been used in place of the parallel RC combination. Different transistors with much larger power dissipations will have to be used to perfect this circuit, since the gain must be increased to 4 and the input impedance to approximately 2.5 K, and the output impedance will have to be lowered to approximately 250 Ω. This is presently being studied.

1.3 Electro-Optical Work

1.3.1 Low-Cost Keldysh Effect Modulator

To eliminate expensive sources and/or filters in the operation of a Keldysh effect modulator one needs to use a differential amplifier circuit.

Such a circuit was constructed and tested. The circuit diagram is given in Fig. 14.

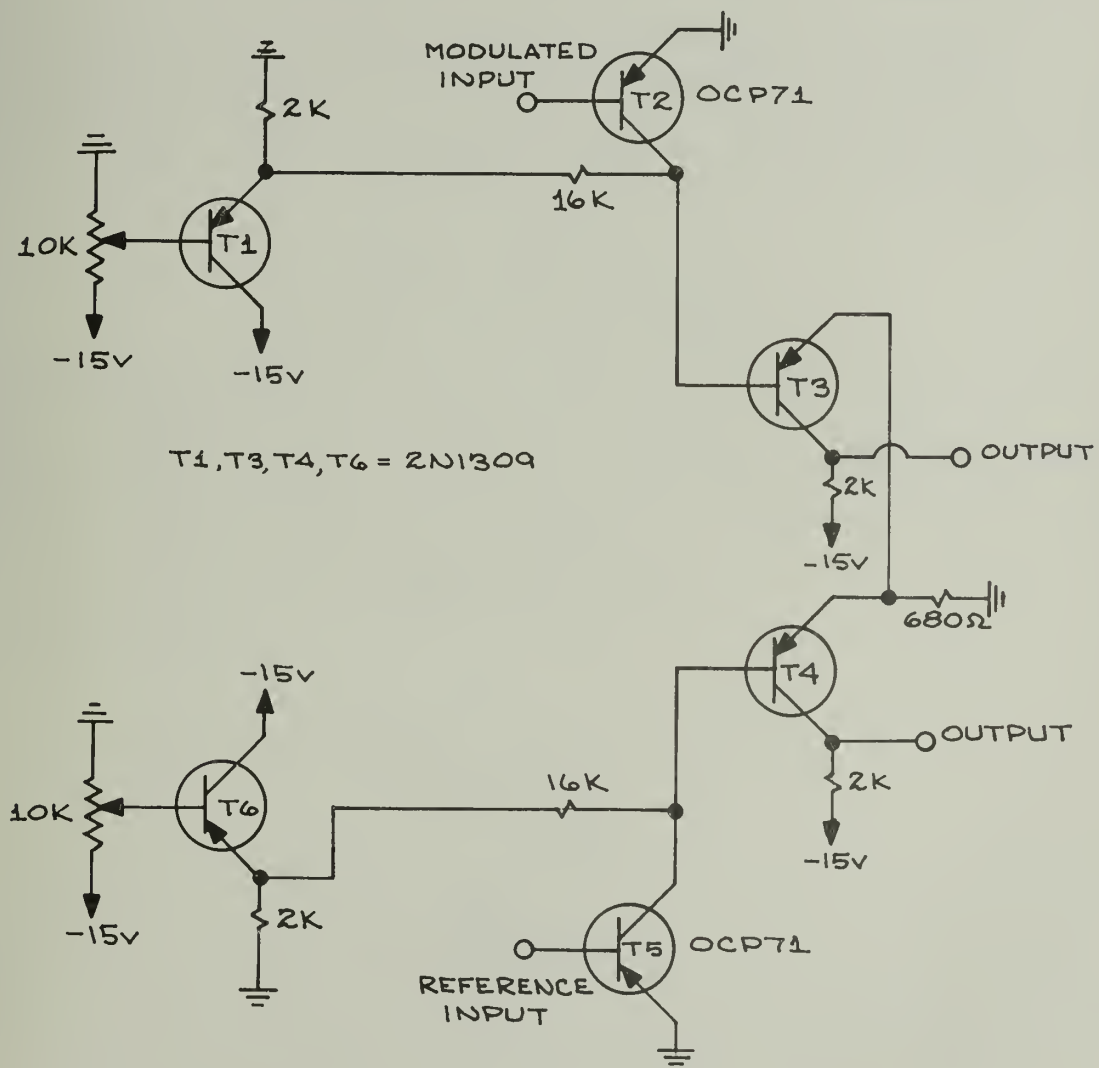

Figure 14. Optical Differential Amplifier

The first two transistors are used simply to supply variable voltages to the OCP 71 photo transistors. The output impedances of these stages are less than 25 ohms. The variable voltage controls the bias level for the photo transistor. This level and the selected 680 ohm emitter resistor set the bias of the output stage. A simple lens system is used to focus the infrared on the photo transistors.

The circuit seems to be quite sensitive. A one per cent change in incident intensity produces a one volt change at the output.

1.3.2 Theory of Optical Modulation by the Keldysh Effect

In order to select samples to show the Keldysh effect properly, further theoretical analysis has been done and a clearer picture has been derived. It has already been shown in the preceding report[1] that the effect of the electric field on the absorption coefficient in the range $\omega < \omega_0$ is

$$\alpha = \frac{4\mu e^2}{\pi n m^2 c \omega} |\vec{e} \cdot \vec{M}|^2 X \int \xi^{\frac{1}{2}} K^2_{\frac{1}{3}}(\xi) d\xi$$

By a change of variables, we have:

$$\alpha = R\theta_F^{\frac{1}{2}} \int_\beta^\infty |Ai(t)|^2 dt$$

with

$$R = \frac{2e^2 c_0^2}{h\omega e n m^2} \left(\frac{2\mu}{h}\right)^{\frac{3}{2}}$$

$$\theta_F^3 = \frac{e^2 F^2}{2\mu t}$$

$$\beta = \frac{\omega_1 - \omega}{\theta_F} \qquad \omega_1 > \omega$$

By evaluation of the integral,[2] we obtain

$$\alpha = R(\omega_1 - \omega)^{\frac{1}{2}} \frac{1}{\sqrt{\beta}} [-\beta|Ai(\beta)|^2 + |Ai'(\beta)|^2]$$

Since β is real and $B > 0$ for $\omega_1 > \omega$, we may write

$$\alpha = R(\omega_1 - \omega)^{\frac{1}{2}} \frac{1}{\sqrt{\beta}} [-\beta Ai(\beta)^2 + Ai'(\beta)^2]$$

In order to examine the effect of changing the field, $\frac{d\alpha}{d\beta}$ is calculated:

$$\frac{d\alpha}{d\beta} = -\frac{1}{2\beta}\alpha - \frac{R(\omega_1 - \omega)^{\frac{1}{2}}}{\sqrt{\beta}} Ai(\beta)^2$$

Since[3] $Ai(\beta)$ and $Ai'(\beta)$ approach zero when β becomes large (it will be a good approximation to take $Ai(\beta)$ and $Ai'(\beta)$ as zero when $\beta > 0$), it becomes obvious that, in order to have a larger variation of α with respect to the change of β, it is desirable to have the value of β falling into the range ≤ 2 as the applied electric field is increasing.

Now we know that:

$$\beta = (\omega_1 - \omega)\left(\frac{2\mu\hbar}{e^2F^2}\right)^{\frac{1}{2}} = 0.78 \times 10^{-9} \frac{k^{\frac{1}{3}}\Delta\omega}{F^{\frac{2}{3}}}$$

where F is the electric field and k is the ratio of effective mass to rest mass of the electron. For those materials whose absorption edge is located in the near infrared range, $\Delta\omega$ is of the order of 10^{12}. Then the applied field has to have an intensity of about 10^4 volts/cm before the absorption coefficient is effectively changed. Therefore, for practical purposes, material with small effective mass, such as GaAs, should be used.

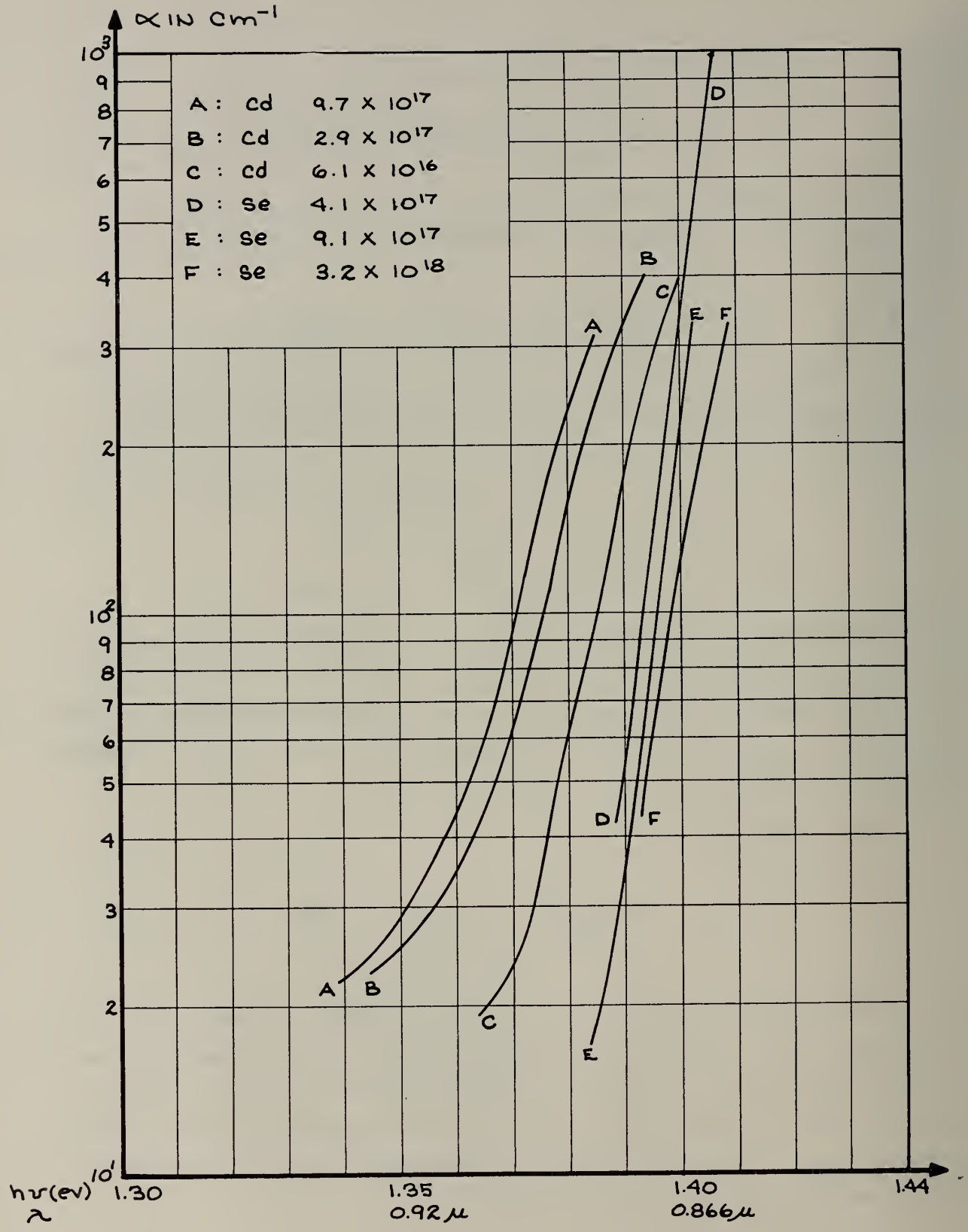

Figure 15. Main Absorption Edge of GaAs With Different Doping Condition at Room Temperature

In addition to the effective mass of the material, another factor which should be considered in specifying the junction is the doping of the material. It It has been shown experimentally that both dopant and doping level will effect the location of the main absorption edge. In GaAs, when the dopant is of the P type, the absorption edge will shift towards the lower energy side with increasing doping density, and when the dopant is N-type the edge will shift towards the higher energy side. A typical experimental curve on GaAs is shown in Fig. 15. It is now understandable that, in a P-N junction, the main absorption edge is dominated by the P-type layer. Therefore, for the purpose of observing the Keldysh effect, the P-N junction should be made in such a fashion that the doping density of the N-layer is heavier than the P-layer. During reverse bias, the space charge region will then exist essentially in the P-region and influence the absorption edge of the P-layer rather than that of the N-layer.

1.4 "Noise Computer"

1.4.1 Multiplication by Random Pulse Sequences

Suppose that we have two sources which generate randomly spaced standardized pulses as shown in Fig. 16.

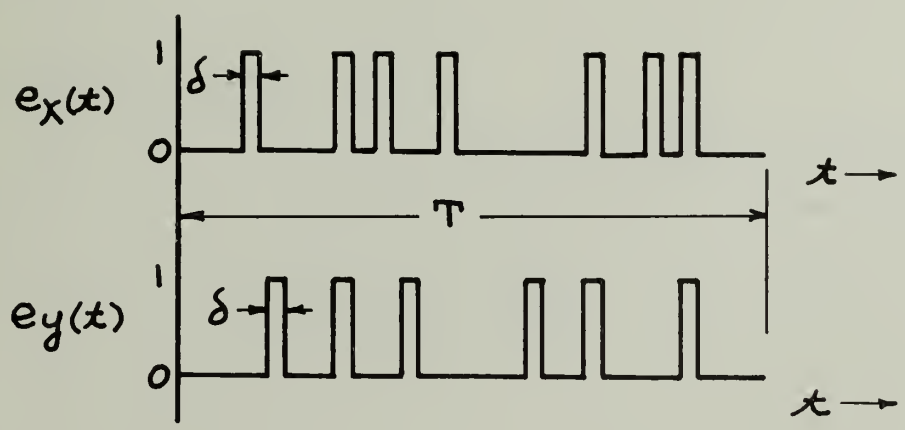

Figure 16. Standardized Pulses

By the term "standardized pulse" we mean that the height and the width of all the pulses are equal.

Let δ: width of the pulse

N_x: number of pulses during a time interval T of $e_x(t)$

N_y: number of pulses during T of $e_y(t)$

1: binary representation for presence of (positive) pulse

0: binary representation for absence of pulse

Then the probability that the pulse is present at any given time is

$$P(e_x=1) = \frac{N_x \delta}{T}$$

provided T is sufficiently large.

Similarly for $e_y(t)$:

$$P(e_y=1) = \frac{N_y \delta}{T}$$

When these two signals are fed into an AND gate the probability that the output of the AND gate is "1" is given by

$$P(e_x=1, \quad e_y=1) = P(e_x=1)\ P(e_y=1)$$

$$= \frac{N_x \delta}{T} \frac{N_y \delta}{T}$$

provided $e_x(t)$ and $e_y(t)$ are independent.

Let x and y be numbers which are given by

$$x = \frac{N_x \delta}{T} \qquad y = \frac{N_y \delta}{T}$$

then the above relation between probabilities means that the output of the AND gate gives the product of x and y in "analog fashion."

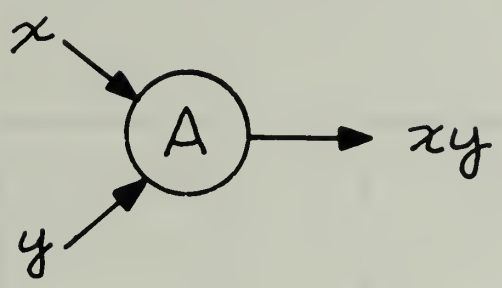

Figure 17. Product AND-Gate

Remark: It is easy to see that the probability densities defined by $p(t)dt$ = probability of observing a pulse during the time interval t, t + dt is given by $p = \frac{N\delta}{T^2}$.

1.4.2 Generation of Random Pulse Sequences

For convenience, let us call a sequence of randomly spaced standardized pulses as explained in simply r andom pulse sequences. In order to realize the system described in the previous section random pulse generators are needed. The diagram in Fig. 18 shows one method of obtaining random pulses.

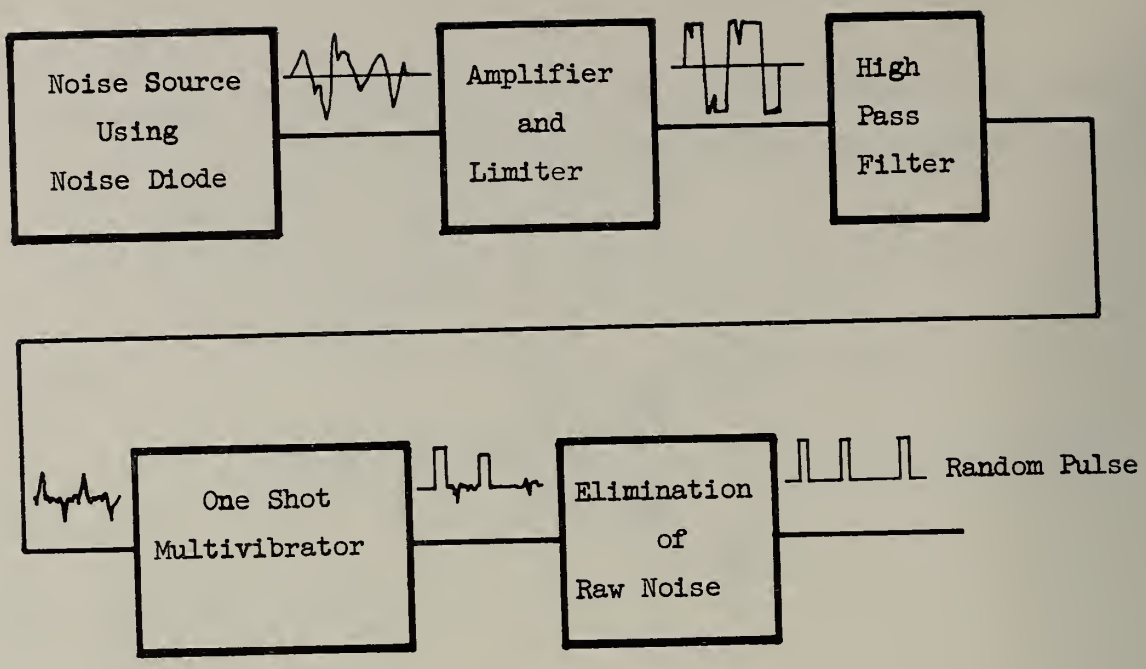

Figure 18. Random Pulse Generator

1.4.3 Test of Randomness by Correlation

The output pulses must be tested to see if they are actually randomly spaced as desired. By the term "random," we mean "nonperiodic." To test this nonperiodicity autocorrelation functions and cross correlation functions are useful.

a) Test by autocorrelation

Let e(t) be the function which we want to test. Since we are not sure that e(t) is random, let e(t) be the sum of a periodic signal S(t) and a random signal R(t).

$$e(t) = S(t) + R(t)$$

Obviously S(t) and R(t) are independent. The autocorrelation function of e(t) is

$$\varphi_{ee}(\tau) = \lim_{T\to\infty} \frac{1}{T}\int_0^T e(t)e(t+\tau)dt$$

$$= \overline{e(t)e(t+\tau)}$$

$$= \overline{[S(t) + R(t)][S(t+\tau) + R(t+\tau)]}$$

$$= \overline{S(t)\ S(t+\tau)} + \overline{R(t)\ R(t+\tau)} + \overline{S(t)\ R(t+\tau)} + \overline{R(t)\ S(t+\tau)}$$

The time average and the ensemble average are equal in the ergodic case (which we shall assume here), the ensemble being all possible e(t)'s.

Let ξ be the amplitude of the (stationary!) ensemble $\{S(t)\}$ and η be the amplitude of the stationary ensemble $\{R(t+\tau)\}$. Then from the ergodic property,

$$\overline{S(t)R(t+\tau)} = \overline{\xi\eta}\text{: ensemble average}$$

Because of the independence of S(t) and R(t),

$$\overline{\xi\eta} = \overline{\xi}\,\overline{\eta}$$

also

$$\overline{\xi} = \text{ensemble average of } S(t)$$

$$= \text{time average of } S(t) = \overline{S(t)}$$

Similarly

$$\overline{\eta} = \overline{R(t+\tau)}$$

$$\therefore\ \overline{S(t)R(t+\tau)} = \overline{S(t)}\ \overline{R(t+\tau)} = \overline{S(t)}\ \overline{R(t)}$$

also

$$\overline{R(t)}\ \overline{S(t+\tau)} = \overline{S(t)}\ \overline{R(t)}$$

Let

$\varphi_{SS}(\tau) = \overline{S(t)\ S(t+\tau)}$: autocorrelation of periodic component

$\varphi_{RR}(\tau) = \overline{R(t)\ R(t+\tau)}$: autocorrelation of random component

Hence

$$\varphi_{ee}(\tau) = \varphi_{SS}(\tau) + \varphi_{RR} + 2\overline{S(t)}\ \overline{R(t)}$$

It is known that $\varphi_{SS}(\tau)$ is periodic with respect to τ, and $\varphi_{RR}(\infty) = 0$. Then $\varphi_{ee}(\tau)$ would have the form as shown in Fig. 19.

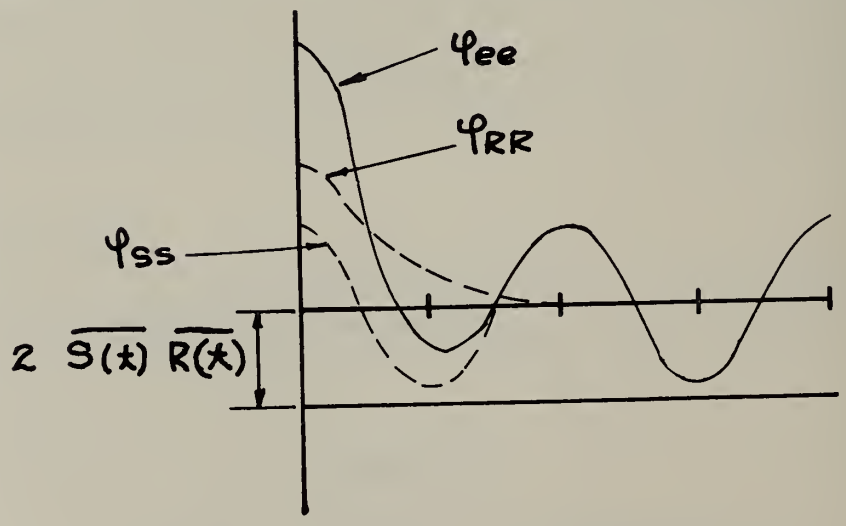

Figure 19. Possible Shape of $\varphi_{ee}(\tau)$

If φ_{ee} is periodic for a sufficiently large τ, we can conclude that e(t) contains a periodical component S(t). On the contrary, if φ_{ee} is not periodic for a sufficiently large τ, e(t) does not contain periodical component S(t). Fig. 20 shows how the actual test is carried out.

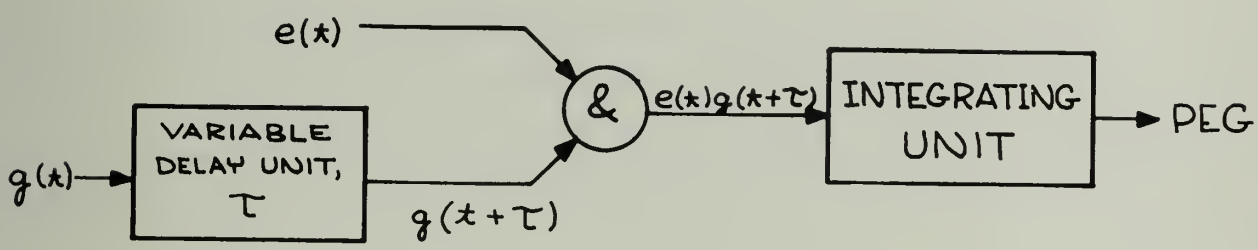

Figure 20. Test of Randomness by Autocorrelation

b) Test by cross correlation

Consider the same signal e(t) as before. Let g(t) be a local periodic signal (for convenience, take a periodic train of standard pulses) with the same period as S(t).

The cross correlation of e(t) and g(t) is

$$\varphi_{eg}(\tau) = \overline{[S(t) + R(t)]g(t + \tau)}$$

$$= \overline{S(t)\ g\ (t + \tau)} + \overline{R(t)\ g(t + \tau)}$$

Again because of the ergodic property

$$\overline{R(t)\, g(t+\tau)} = \overline{R(t)} \cdot \overline{g(t+\tau)} = \overline{R(t)} \cdot \overline{g(t)}$$

Let

$\varphi_{Sg}(\tau) = \overline{S(t)\, g(t+\tau)}$: cross correlation between the periodic component of e(t) and the local periodic signal

$$\varphi_{eg}(\tau) = \varphi_{Sg}(\tau) = \overline{R(t)} \cdot \overline{g(t)}$$

It is known that $\varphi_{Sg}(\tau)$ is periodic with respect to τ, whereas $\overline{R(t)} \cdot \overline{g(t)}$ is independent of τ, i.e., constant. Hence if there is a periodic component in the cross correlation, e(t) must have periodic component. On the contrary if there is no periodic component in the cross correlation, e(t) must be random.

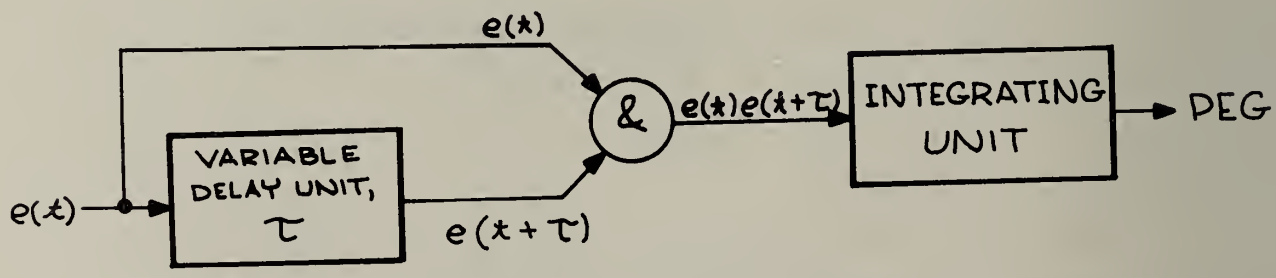

Figure 21. Test of Randomness by Cross Correlation

In this case the necessary range of τ is: $0 \leq \tau <$ period of g(t). The period of g(t) must be varied in the region in which we are interested.

BIBLIOGRAPHY

[1] "Quarterly Technical Progress Report," Department of Computer Science, University of Illinois, Urbana, Illinois, October, November, December, 1964.

[2] H. Jeffreys and B. S. Jeffreys, "Methods of Mathematical Physics," Cambridge Press, 1946.

[3] M. Abramowitz and I. A. Stegun, "Hand Book of Mathematical Functions," National Bureau of Standards, 1964.

[4] Dale E. Hill, "Infrared Transmission and Fluorescence of Doped Gallium Arsenide," Phys. Rev. 133, A866(1964).

2. COMPUTER SYSTEMS RESEARCH

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2.1 A Prototype Time-Sharing Monitor

2.1.1 General Description

This monitor was written as a first approximation to a control for a time-sharing system, in an attempt to discover what problems a practical application of time-sharing would disclose. Written to apply more generally methods previously developed on AEC, Automatic Engineering Control (see File No. 622), this monitor was subsequently used on March 12, 13, 1965, for the Engineering Open House. Thus, it is called the Open House Monitor (OHM).

The monitor was used to control six routines (user programs). Two of these were dummy programs which were used as background and merely kept the accumulator busy. The remaining four are:

A. Typewriter Control--a control which allows selection of a subprogram. Some programs are merely output messages to the user, but the following two were actually "played" on the typewriter:

   1) Typewriter Test--the user inputs a message and ILLIAC II (in reply) outputs the same message.

   2) Day-of-the-Week--the user specifies a date, e.g., 3/10/1965, and the program supplies the answer: March 10, 1965, was a Wednesday.

B. Tic-Tac-Toe--the user attempts to "beat the machine" on a 3-dimensional $4 \times 4 \times 4$ playing board connected to one of the input/output device special registers.

C. Alpha-Dem--the user feeds in a message on paper tape and ILLIAC II punches out the message in block "billboard" letters.

D. SOC-Simple On-line Calculator--this is an ILLIAC II program to allow an IBM 1050 remote console typewriter to be used as an intelligent, conversational desk calculator. (See the description following.)

Each program is initially run in sequence for a pre-defined quantum of time (2/15 sec. was used) until an input/output device is requested. OHM then deactivates the user program and--still cycling through the other programs--uses interrupt signals from the requested unit to load or unload the proper buffer. When the input/output sequence is completed, the user program is reactivated and is run in sequence as before.

2.1.2 Limitations and Difficulties Encountered

No two programs shared an input/output device, so although this feature was considered in the writing of OHM, it was unable to check for actual difficulties arising from such use.

It was noted that due to the use of a hierarchy in the checking of interrupt conditions, one program often tended to dominate use of the monitor input/output routines. This condition could be alleviated by having a time-sharing monitor periodically check all interrupt conditions regardless of hierarchy.

Due to hardware malfunctions of the newer peripherals (interrupt signals not being detected, timing errors, etc.) various user programs occasionally hung up. In such cases, it was often necessary to restart the entire system. Obviously correction and diagnostic procedures which will selectively reinitiate parts of the system are needed.

Research use of OHM shall continue in an attempt to "weed out" difficulties of a time-sharing system.

2.2 SØC--A Console Calculator Language

With the aim of producing a quickly and easily used remote console language, the SØC (Simple Online Calculator) language has been developed using some of the techniques developed for the CLIC (Console Language Immediately Compiled) language. SØC is an ILLIAC II program to allow remote consoles to be used as conversational, intelligent desk calculators.

The user can assign a value to any letter of the alphabet by typing in a statement such as FORM A = 2 + 2, and ILLIAC will type back the answer:

A = +.40000000E + 01

Statements to assign a value to a letter may use any of the following signs or operators:

+	addition
-	subtraction
*	multiplication
/	division
**	exponentiation (raise to the power)
(	left parenthesis
)	right parenthesis

Numerical values used in the assignment statement may be in integer or floating-point form; however, all SØC calculations are done in floating point. The letters for which values have been assigned may be used in later statements to assign values to other letters. Thus SØC can be used to perform complicated calculations.

SØC will also calculate the following functions of α, any arithmetic expression:

sin	[α]	sine of α degrees
cos	[α]	cosine of α degrees
elog	[α]	natural logarithm of α
tlog	[α]	logarithm of α to the base 10
atan	[α]	arctangent of α
sqrt	[α]	square root of α
exp	[α]	e raised to the power α

These functions may be used as a value in any statement.

All operations in SØC are initiated by the user typing in one of seven verbs followed by the required statement. The seven verbs are: SET, FORM, TYPE, DUMP, FOR, HEAD. The function of each of these may be seen by the following examples:

SET

Typing the following:

SET A = 10., B = A, C = A + B

results in setting the variables A and B to 10, and variables C to 20.

FORM

Typing the following:

```
FORM A = 10., B = A, C = A + B
```

will set the variables and cause SØC to type back the answers:

```
A = +.10000000E + 02   B = +.10000000E + 02   C = +.20000000E + 02
```

TYPE

Typing the following:

```
TYPE A, B, C
```

will cause SØC to type out the current values of the variables listed:

```
A = +.10000000E + 02   B = +.10000000E + 02   C = +.20000000E + 02
```

DUMP

Typing DUMP will cause all 26 variables (letters of the alphabet) to be typed out with their current value.

CLEAR

Typing CLEAR will set the value of all the variables to zero.

FOR

Typing the following:

```
FOR X = 1, 2, 5, 7
```

results in the next FORM statement typed to be evaluated for X = 1, X = 2, X = 5, and X = 7. When under FOR control, SØC will respond with

```
FOR X = +.10000000E + 01
          [result of FORM statement]
```

```
FOR X = +.20000000E + 01
          [result of FORM statement]

FOR--etc.
```

Typing the following:

```
FOR X FROM 1 TO 10
```

will result in the next FORM statement being evaluated for X = 1, 2, 3, 4, ..., 8, 9, 10, i.e., increments of 1.

Typing the following:

```
FOR X FROM 1 TO 10 IN STEPS OF 2
```

will result in the next FORM statement being evaluated for X = 1, 3, 5, 7, 9, i.e., increments of 2.

HEAD

Typing HEAD will set up SØC to take in a heading that will be placed before each output. Thus SØC may be used to turn out tables and reports. A heading may be removed by typing a CLEAR or DUMP verb which causes the calculator to return to normal output format in addition to performing the regular function of the CLEAR or DUMP verb.

If the user makes an error, SØC will type out an appropriate comment, and allow the user to try again.

The SØC project required insignificant effort in view of the power and usefulness of the resulting program. The majority of the routines were taken directly from the CLIC language and linked together with a routine to interpret the code output of the CLIC compiler.

The first public use of SØC was during the Engineering Open House, (March 12-13, 1965) when it was time-shared with the other routines running on ILLIAC at this time.

In the near future, SØC will become the first remote console routine to be time-shared with the batch processing system during the normal ILLIAC II operating schedule.

2.3 Disk File Interplay Channel

The 1301 channel is presently in the final stages of debugging. The channel functions as intended both while connected to ILLIAC V, the computer simulator, and while in the ILLIAC II system. All instructions are being properly initiated and all timing conflicts have been resolved. Changes in the design of the channel which make portions of File No. 620 (Programming Aspects of the Disk File Channels) obsolete, will be issued shortly.

Both Module 0 and 1 of file frame B have been given "seek" exercise with ILLIAC V. Module 0 functioned perfectly, but Module 1 developed minor mechanical problems. All cylinders on both modules have also been correctly formatted, but due to some malfunctions in the IBM 7631 File Control, few actual data transfers have been accomplished. Once this fault is localized and corrected, the channel should be ready for use.

Engineering test programs, basically relying on modified versions of the disk subroutines prepared by D. Collins and R. E. Willard, have been written to aid in the debugging when the channel is on-line. A program which simulates ILLIAC V on ILLIAC II, and which is controlled by SR 76 and SR 34 has been found very useful in establishing that the channel responds to ILLIAC II in the same manner as it did to ILLIAC V while off-line. Because of the speed with which one can alter a test at the console, this routine should also be useful in the future for engineering purposes if the channel develops circuit troubles.

2.4 Device Interface Register

A general purpose Special Register ($SR52_8$) for interfacing slow input/output devices to ILLIAC II has been designed. This Special Register is similar to $SR76_8$, but offers more options to the external device. This register will be used in the near future to attach an Autotutor* to ILLIAC II.

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* See Digital Computer Laboratory File No. 611.

2.5 Multiplexing Special Register System

The hardware associated with the Multiplexing Special Register System has been debugged. This equipment is currently being used in conjunction with ILLIAC V to facilitate the check-out of hardware for the Engineering Inquiry Console and the Teletype Special Register.

2.6 Computer Simulator (ILLIAC V)

A logic design has been completed for the addition of a Teletype paper tape reader to ILLIAC V; this greatly extends the capabilities of ILLIAC V for dealing with slow input/output devices.

2.7 Engineering Inquiry Console

The Engineering Inquiry Console, consisting of a Teletype 8-level keyboard for input and an IBM B1 typewriter for output is currently being debugged off-line.

2.8 Teletype Special Register

A logic design has been completed which will permit ILLIAC II to communicate, via the Multiplexing Special Register System, with Teletype equipment operated in the dc loop mode. This Teletype Special Register contains all necessary timing circuitry and shift-registers for serializing and deserializing ASCII characters. Circuits have been designed to convert standard NOR levels to the neutral (20 ma) Teletype line levels.

2.9 CAVITIES

A new engineering testing program system has been generated: the Condensed, Automated, Variably-Indexed Type Integrated Engineering System. CAVITIES, the successor to STRIPE and CREST, offers many new features for operator convenience and extended flexibility.

2.10 Diode Recovery Testing

Work has begun on a new diode speed tester. The major problem previously has been that the cycling of the test was so slow that only an extremely dim trace was visible on the Tektronix 585 oscilloscope. Since electrical requirements eliminate the use of any presently available electronic means of cycling the test, a search was under taken to find a mechanical switch faster than the 60 cps mercury relay now in use.

The search was successful resulting in the discovery of a dry reed relay capable of opening and closing at a rate of 3000 operates per second. Initial work shows that this switch can provide signals with rise times less than one nanosecond. Using this switch to control the test cycling the trace on a Tektronix 585 is bright enough to be seen in almost normal room light. This work continues.

2.11 The Semiautomatic Component Tester

The cabinet panels for SPECTAR were painted and installed. The front operating panel is protected by a piece of clear plastic.

The installation of the panels necessitated the neatening of the external control wiring. This wiring was replaced and recabled as necessary.

It was noted that the test relay turn-off sequence allowed the test socket to be unshorted when the power supplies were disconnected from the test. It was felt that the possible surges that this could cause in a semiconductor being tested should be eliminated. Consequently, the turn-off sequence was modified so that the test socket is shorted before the power supplies are disconnected.

Two errors were found in the data recording system of SPECTAR. The first one found was that every thirty to one hundred times the PUNCH DATA button was depressed the DVM would be reset to zero causing the recording of incorrect data on the paper tape. Investigation disclosed that occasionally there was an erratic pulse inside the DVM on the reset line although this line has no external connection. It is believed this pulse is caused by coupling into the DVM from cables carrying the 100 volt punch solenoid signals since no internal fault could be located within the DVM. Hopefully, the new set of shielded cables will eliminate this problem.

The second error found was that when the DVM is reading over-range, the internal trigger causes the binary counters inside the DVM to continue counting. Because these counters act as the memory of the logic unit while data is being punched on tape, it is necessary they remain static during the punching cycle. This problem will be cured by using the PRINT INHIBIT signal from the DVM to prevent the logic from starting the punching cycle until after the over-range condition is relieved.

The decision by the ILLIAC II Systems Programmers to use another 512 words of high core for systems' routines is unfortunate since the present program for SPECTAR uses all but 20 words of available core. As a consequence, rewriting of the program has been started to keep most of the test data stored on the drum. The new program will occupy about 4000 words of core and up to 64 blocks of drum will be used as storage.

3. ILLIAC II SERVICE USE AND PROGRAM DEVELOPMENT

(This work is supported in part by Contracts No. AT(11-1)-415 and No. AT(11-1)-1469 of the Atomic Energy Commission and in part by the University of Illinois.)

The use of ILLIAC II by users outside of the Laboratory has increased this quarter because of the introduction of additional runs during the day (now 6) and on the weekend. Also, ILLIAC has been processing jobs which are handed in with a white ID card. These have accounted for 15 to 20 runs per day.

As last semester, Math 195 FØRTRAN homework is being processed on ILLIAC. The introduction of a special operating system which compiles in two to three seconds and typically executes in less than one second has reduced the time spent on Math 195 jobs to a half hour maximum during peak loads, assuming no machine malfunctions requiring operator intervention.

The following sections describe the program development, machine use and maintenance figures respectively.

3.1 Program Development

3.1.1 Progress

This quarter has seen a general reorganization of the group into service and research divisions. The service group is responsible for maintaining the system and aiding the user as well as developing new system and library routines. The research group will be working on developing a time-sharing monitor and executive scheduler which will (among other things) tie in with a new peripheral or satellite computer. The peripheral computer will receive information from the remote consoles and help take part of the load of receiving lines from the ILLIAC.

New meetings have been initiated to keep all the programmers in touch with work being done in other parts of the Laboratory. A working group to plan the essential features of the new monitor is also under way.

It has been decided to push library subroutine development. Work has begun on a graphing program, a numerical integration routine, and solution of ordinary differential equations. A general purpose dump routine which can be called during execution and a timing routine will soon be put on the library tape.

An additional part of the system manual dealing with FØRTRAN has been issued. The study of macros in NICAP continues and several minor changes of FØRTRAN are ready for a future update of the compiler.

A new system tape for Math 195 was generated with FØRTRAN and some of the library subroutines on the drum. This has reduced compile time to two to three seconds per job.

The interrupt system as stated in the last report is working both on and off-line with typewriter messages to the operator and an expanded monitor and SYSERR message and dump program. SYSIØ has been altered to read two cards per record; a new more efficient 1401 program is being developed; SYSETC has been expanded to include SETUP, trap (if called for) on too many tape or drum errors, trap (if called for) on end of tape, and read the clock.

Aside from furthering system development, efforts in the next quarter will be partly directed toward documenting already existing programs.

Plans are being made for organizing and systemizing tapes, cards, write-ups, and general procedures to be followed in updating tapes and instituting new practices for the operation of the system. Closer cooperation with the engineers and operators is becoming a reality.

3.1.2 System Program Development

During this period, a new off-line batch processing system was incorporated with an improved on-line batch processing system. This included a major revision of the system core loading procedure, and resulted in a new format for the system tape.

Use of the typewriter for ID cards printout and messages to the operator was included forthe first time. Plans are being made to expand the typewriter program to include input from the operator. The typewriter program

is used by the interrupt program to enable simultaneous use of typewriter print-out and the current users program. In order to simplify the writing of coded typewriter messages, a routine which converts BCD to its equivalent typewriter code has been programmed and is used in the monitor error routine.

The batch processor itself was expanded to provide automatic user timing and a time card to facilitate account keeping. A program has been completed which will preprocess the time cards in order to make them compatible with the 7094 accounting program. SYSIØ was written to work off-line on the 1414's and to process two cards per record. It includes an output record counter which makes an error message exit when the specified output maximum is exceeded.

The new monitor provides for the use of interrupt with automatic recovery from fatal program and machine errors.

The disk files and their properties were studied so that flexibility could be allowed for in the system program. A format for the parameters was decided upon. The part of SYSAUX dealing with the disk files has been programmed and is waiting for the physical disks to be ready in order to begin code-check.

Section 7.1 of the User's Manual giving the details of Version I of FØRTRAN II for ILLIAC II is nearing completion. Work is progressing on rewriting the User's Manual.

Library subroutines have been updated and added. The new write-ups of these routines will be distributed in April and the corresponding copies of the routines will be kept on cards in the files of the Department of Computer Science. The routines which have been updated are:

Print-Read-Bunch

ATAN1	SIN1
ATANF	COS1
SQR1	PTFW
SQRTF	PTQW

The new routines are

Cube Root

Time Routine

SLQ2

SIN2-CØS2

A nonterminating dump program with many options has been written for users and will soon be available on the library tape.

The Compiler[2] has progressed slowly during the last three months. When the time came to actually try to generate code various problems arose and in one form or another, they are still being dealt with. The primary problem has been the machine independent intermediate code which was originally specified in a very idealized way. It has since been transformed to include a number of special orders--orders designed to convey more of the information contained in the syntax of the source language over to Phase II to aid in code generation. The table rebuilder for Phase II is also being constructed and rudimentary code generation should be possible as soon as the tables are available from the 7094 Phase I.

3.13 FØRTRAN, the ILLIAC II Compiler (Version I)

The documentation of Parts 1, 3, and 4 of ILLIAC II--FØRTRAN II was published this quarter for the NICAPS System Manual. Writing has continued on Part 2, the control statement generator section.

Also several minor changes have been completed and are ready for a future update of the operating FØRTRAN II compiler on the system tape. They are:

A. a change in the format of the listing of the FORTRAN II source language and error messages putting the sequential card number on the left for greater reliability;

B. a change in indexing so that if an indexed variable has fewer indices than the variable as dimensioned, it will consider the needed indices to be ones (the case of no indices given a dimensioned variable has compiled to be the first element of the array previously); and

C. changes in the error messages of the CØMMØN and EQUIVALENCE statements.

The coding changes have been made and code checking is proceeding to extend the set of subroutine or function output parameters to include indexed variables.

3.1.4 NICAP, the ILLIAC II Assembler

The initial coding for a MACRO prepass to the NICAP assembler was begun. Code, implementing the basic instructions MACRO and END, has been written and is currently being code checked. Upon completion of this basic package, the vocabulary will be expanded to include all operations described in SCATRE Manual.

3.1.5 Program Plans and Development

The system tape is to be further changed and the monitor greatly expanded to four blocks in order to provide for a single time-sharing system, to include minor revisions in the present system, to incorporate disk file use, and made general enough to accomodate the proposed system involving a peripheral computer. Programs such as an I/O routine and time-sharing processor for the remote consoles and the batch processor are being written. An input-output routine for us use with the IBM 1050 should be running in a short time. It is presently being code-checked and worked into a program which will time-share with the batch processor on a limited basis.

Progress is being made on the incorporation of disk dumps into the present SR34 dump program.

3.1.6 Library

A numerical integration subroutine for systems of simultaneous linear first order differential equations is presently being written. A sixth-order predictor-corrector method is being used; the Adams-Bashford method is the predictor and Adams-Moulton is the corrector. The user will be able to specify whether he wants fixed step size or automatic step change. At present, starting methods are being investigated and the automatic step change is being programmed.

A subroutine for solving ordinary differential equations by hybrid methods is being programmed.

A library program which will produce graphs on the off-line printer is now being planned. The program will parallel the present 7094 library program with respect to parameters and output but will not use the same methods to plot the graph. Perhaps a more general graph routine will follow this one.

Suggestions for other library subroutines are being received with gratitude.

TABLE 1. ILLIAC II LOG SUMMARY--JANUARY, FEBRUARY, MARCH, 1965

	January	February	March	Totals
ENGINEERING				
General Engineering	287:27	101:56	142:48	532:11
Core Engineering	31:30	38:05	7:10	76:45
Typewriter Engineering	1:15	:35		1:50
1414 Engineering	30:43	15:30		46:13
Interrupt Engineering	1:00			1:00
7631 Engineering	5:00			5:00
Disk (1301) Engineering	3:25		11:40	15:05
1050 Engineering			11:55	11:55
Subtotals	360:20	156:06	173:33	689:59
ENGINEERING TESTS				
Mastic	:15			:15
DAMN	4:50		:25	5:15
AEC	119:54	141:58	198:34	460:26
BTC	:56			:56
Duplex Memory	5:15	5:15	1:29	11:59
Mersenne	7:58	:10		8:08
TTC	13:34	3:47	1:02	18:23
Stripe		:10		:10
Crest		2:50		2:50
KETPG			4:48	4:48
Subtotals	152:42	154:10	206:18	513:10
CODE CHECKING				
Regular Code Checks	72:49	57:21	55:59	186:09
Special Code Checks	3:49		3:45	7:34
Math 195	15:00		3:43	18:43
Subtotals	91:38	57:21	63:27	212:26

TABLE 1 (Cont'd). ILLIAC II LOG SUMMARY--JANUARY, FEBRUARY, MARCH, 1965

	January	February	March	Totals
PROGRAM USE (Not including code checks)				
Systems Development	51:05	124:47	98:31	274:23
System Research	60:00	135:00	150:55	345:55
Production		5:19	11:01	16:20
Subtotals	111:05	265:06	260:27	636:38
DEMONSTRATIONS				
Engineering Open House			21:45	21:45
Demonstrations			:55	:55
Subtotals			22:40	22:40
MISCELLANEOUS				
Down	:05	14:10	1:40	15:55
Idle	28:10	23:22	14:25	65:57
Unknown		1:45	1:30	3:15
Subtotals	28:15	39:17	17:35	85:07
GRAND TOTALS	744:00	672:00	744:00	2160:00

TABLE 2. ANALYSIS OF TIME FOR QUARTER

Percentage of Time Used for Engineering	31.9
Percentage of Time Used for Engineering Tests	23.7
Percentage of Time Used for Productive Use (Code checks, individual use, demonstrations)	40.4
Percentage of Time for Miscellaneous (Down, idle, unknown)	4.0
Total	100.0

3.2 Engineering Maintenance Statistics

3.2.1 Maintenance:

3.2.1.1 Checking Transistors

a. January	26:25
b. February	11:04
c. March	3:00
Total	40:29 hours

3.2.1.2 Systematic Component Replacement

a. January	2:40
b. February	----
c. March	1:00
Total	3:40 hours

3.2.1.3 Marginal Voltage Testing

a. January	11:05
b. February	1:30
c. March	3:30
Total	16:05 hours

3.2.1.4 Checking Collector Bumps, Base Bumps, Zeners and Cable Drivers (Note: A systematic program was started in December in an attempt to make a high-level operating machine.)

a. January	72:36
b. February	2:25
c. March	3:05
Total	78:06 hours

3.2.1.5 Component Replacement Tests

a. January	----
b. February	11:00
c. March	----
Total	11:00 hours

3.2.1.6 Modifications to Machine Logic

a. January	----
b. February	----
c. March	15:05
Total	15:05 hours

3.2.2 Component Distribution:

3.2.2.1 Main Machine

Transistors	43,869
Diodes	82,026
Capacitors	33,908
Resistors	98,713
Total	258,516 components

3.2.2.2 Printed-Circuit Boards (I/O channels)

Transistors	15,014
Diodes	52,351
Capacitors	6,895
Resistors	42,913
Total	117,173 components

3.2.2.3 Total Number of Components Used 375,689.

3.2.3 Component Failures

3.2.3.1 Main Machine

Transistors	94
Zeners	4
Diodes	5

Note: Core 0 had a "catastrophe" which accounted for 79 transistors and five diodes.

3.2.3.2 I/O Equipment

Number of printed-circuit cards used equal 1,859.

Number of printed-circuit cards replaced:

a.	January	10
b.	February	27
c.	March	20
	Total	57 cards

3.2.4 Malfunction of IBM Equipment Requiring Services of Customer Engineers

Equipment	January	February	March	Total
1401	8	7	3	18
Card Preparation	2	6	5	13
Storage (tape and disc)	14	6	11	31
Selectric Typewriter	3	3	2	8
Totals	27	22	21	70

4. THE ILLINOIS PATTERN RECOGNITION COMPUTER: ILLIAC III

(This work is supported in part by Contract No. AT(11-1)-1018 of the Atomic Energy Commission.)

4.1 Bibliography

The following file numbers have been issued to date in this contract year:

Foster, D. "Operating Manual for the Program-Controlled Semiconductor and Printed-Circuit Board Test Console." File No. 639, December 23, 1964.

Foster, D. "Specifications for Internal Drawer Wiring of ILLIAC III Printed-Circuit Card Drawers." File No. 550-54, April 9, 1965.

Greninger, Larson. "Formal Syntactic Techniques for the Optimization of Arithmetic Expression Calculations." File No. 637, January 11, 1965.

Hazelhurst, J. H. and B. H. McCormick. "WEB: A Language to Describe the Interconnection and Packaging of the Logical Units in a Digital Processor. Part I: Preparation of Input Data." File No. 625, August 17, 1964; revised February 10, 1965.

Lieman, Daniel S. "Description of the WEB Wiring Table." File No. 642, February 4, 1965.

McCormick, B. H., J. R. Witsken and H. R. Johnson. "Executive System of ILLIAC III: A Preliminary Description." File No. 645, March 16, 1965.

Mayberry, Billy. "A Summary of ILLIAC III Stalactite Circuit Testing." File No. 640, February 4, 1965.

Northcote, Robert S. and Albert J. Steiner. "A Syntax Loader and Subscanner for a Compiler-Compiler." File No. 633, December 1, 1964.

Ray, Sylvian R. "Assorted Topics in Automatic Document Retrieval." File No. 631, October 19, 1964.

Ray, Sylvian R. "Details of Transfer Memory Input/Output Signals." File No. 630, November 3, 1964.

Sekerke, Jeffery. "Quality Test of High-Current Contactors." File No. 634, November 25, 1964.

Witsken, John R. "A Preliminary Study of the Executive Routine and Console File Control of ILLIAC III." File No. 627, August 19, 1964.

4.2 Summary Article

The following summary article (to be presented at IFIP Congress 1965, New York City (May, 1965))

ILLIAC III: A PROCESSOR OF VISUAL INFORMATION

by

Bruce H. McCormick
Sylvian R. Ray
Kenneth C. Smith
Shigeharu Yamada

is reproduced on the following pages. A more detailed expository paper is in preparation.

An outline for visual data processing using the Illinois Pattern Recognition Computer (ILLIAC III) is presented. The input image is digitized by a TV-like scan, then digitally filtered and idealized to a line drawing in the Pattern Articulation Unit. Upon output from this unit the image is described by a string of displacement vectors, appropriate for an incremental plotter with coordinate stack storage. Subsequent recognition consists of programmed syntactic and semantic analysis of the vector string description[1] using an enriched repertoire of list processing instructions.

1. Computer Organization

ILLIAC III is a multi-processor computer system. Eight terminal groups [Taxicrinic Units (4), Monitor Control Units (2) and I/O Channel Control Units (2)] access in parallel the centralized processors of the computer (Figure 1).

These centralized processors include the three storage groups. Each storage group consists of a fast core module (16,384 double words, 1.2 μsec), a slow core module (65,536 double words, 4 μsec), and a dictionary (fast mostly-read memory). A final group of shared processors includes two arithmetic units[2] and the novel parallel processor for visual data processing--the Pattern Articulation Unit.

Visual input to the computer enters through flying spot CRT scanners: two for 70-mm film, two for 46-mm film, two for 35-mm film and two for microscope slides. Two modes of raster scanning are provided: raster mode, where cell-by-cell the image is encoded uniformly in 1, 2, 4, or 8 bits of gray scale; and coordinate mode, where each black/white transition triggers the readout of 16-bit X(Y) coordinates. Raster mode is the normal recognition scan input; coordinate mode is primarily reserved for precision measurement purposes.

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1. Narasimhan, R. "Labeling Schemata and Syntactic Descriptions of Pictures," Information and Control, Vol. 7, pp. 151-179, (1964).

2. Robertson, J. E. "Methods of Selection of Quotient Digits During Digital Division," IFIP Paper. May 23-29, 1965, New York.

Visual output of the computer again uses the film scanners, which can also operate as film cameras. Display modes include the write version of the raster and coordinate scan described above. In addition a vector display mode--where the CRT scanners operate as incremental plotters with stack memory--is provided.

To assist human intervention, monitor stations (each provided with CRT display, typewriter and incremental magnetic tape unit) are made an integral part of the system.

2. Image Idealization

Strips of the input picture are scanned (in raster mode) into fast core storage. A two-dimensional segment of the image, 32 × 32 bits, (called a "window") is then word-serially loaded from computer storage into the Pattern Articulation Unit (PAU). Within this processor subsequent digital idealization of the window image proceeds in parallel, (i.e., in the 1024 + 132 cell modules of the iterative array). The PAU is controlled by a string of instructions transmitted by the controlling Taxicrinic Unit (or monitor).

The input image is normally idealized to a line drawing. In particular local filtering algorithms which utilize both the stochastic characteristics of the image noise and definition of the idealized picture have been developed (see Figure 2).[3,4] Notice the extent to which burst noise in the original image has been correctly compensated.

3. Scan Conversion: The Articulation Process

With the image idealized, the second role of the Pattern Articulation Unit can be visualized as a scan conversion: from raster mode input (i.e., TV-like scan) to vector mode display output. That is, we take a particular incremental plotting language as the primitive basis for image description.

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3. Yamada, S. "Local Recognition of Pictorial Images," Department of Computer Science, University of Illinois, Urbana, Illinois. Report in preparation.

4. James Fornango programmed the filtering algorithm demonstrated in Figure 2, University of Illinois, Urbana, Illinois.

The displacement vectors generated are single characters ($\pm \Delta X$, $\pm \Delta Y$) with $0 \leq X \leq 7$, $0 \leq Y \leq 7$. When $\Delta X = \Delta Y = 0$, the sign information is used to designate control instructions.[5] Specifically control instructions allow one to push (pop) the current (X,Y) coordinate pair into (out of) a coordinate stack.[6] The incremental plotting language, so interpreted, provides a compact description language for the image outlines previously created.

The mechanism of this scan conversion is the pattern articulation process illustrated in Figure 3. Here the window image has been idealized and critical nodes (i.e., basic sets) isolated by parallel processing. The crucial remaining step, we observe, is to reestablish the connectivity between these critical nodes. Connectivity of the image can be indicated by (1) listing nearest neighboring nodes to a given node, or alternately by (2) generating a vector string which, if sent the incremental plotter, would draw straight line vectors to these neighboring nodes. Both options [(1) and (2)] are provided directly by wired-in control logic of the PAU.

Figure 4 suggests schematically the critical PAU facilities that permit rapid listing of neighboring nodes. First two associated windows must be identified: (1) the idealized image and (2) the set of critical nodes of the image. The PAU through a program-controlled path building facility, allows fan out from the point of initial excitation generating the image S0. Using planewise Boolean logic the complement of the M' plane is $S0 \cdot \overline{S6}$. A wired-in coordinate scan then automatically lists either the coordinates of these neighboring points, or alternatively their vector string representation.

4. Current Engineering Status

Two-thirds of the Pattern Articulation Unit have now been fabricated. Each cell module (of the 1024 + 132 cells) of the iterative array is a 5"-x-5" printed-circuit card. Each card houses approximately 200 microdiodes and 45 transistors. Seven scanners and five monitors are now nearing completion.

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5. H. P. Peterson has implemented a related 12-bit vector display code. Control Data Corporation, Digital Graphics Division, Burlington, Massachusetts.

6. Breeding, K. J., McCormick, B. H., and Witsken, J. R., "Order Code for the Film Scanners of ILLIAC III," Department of Computer Science, University of Illinois. Report now in preparation.

Two Taxicrinic Units are under construction. These units provide list processing instructions, memory protection, and the facility to directly execute without programmed intervention all macro instructions satisfying certain formal call format conventions.

From simulation studies, processing turn of ILLIAC III for visual information can be estimated at 0.5 - 1 msec/window or approximately 1 sec for a $10^3 \times 10^3$ bit picture. We assume the material is scanned at a magnification such that window image identification is not obscured by black/white encoding of the 32×32 bit fragment.

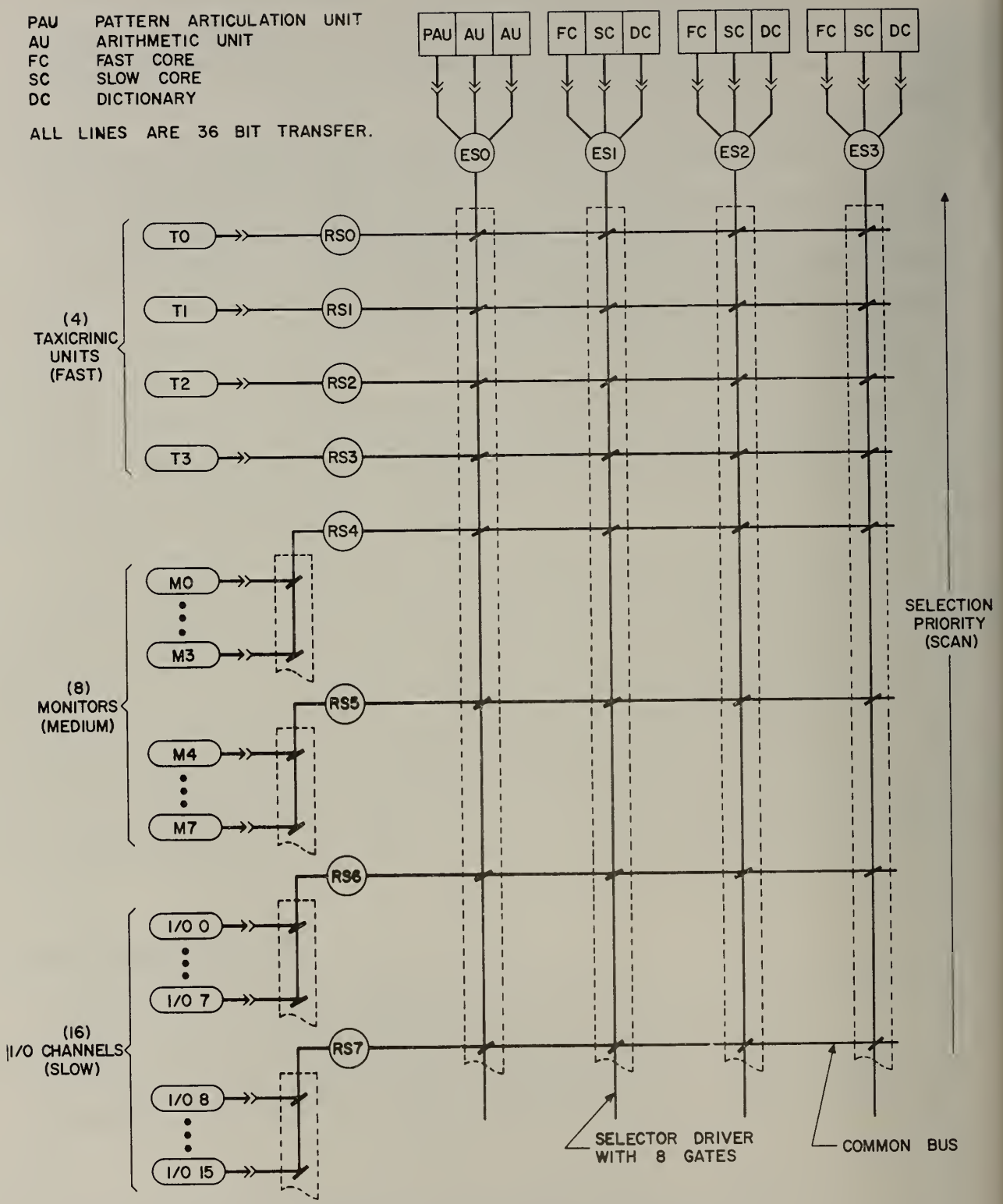
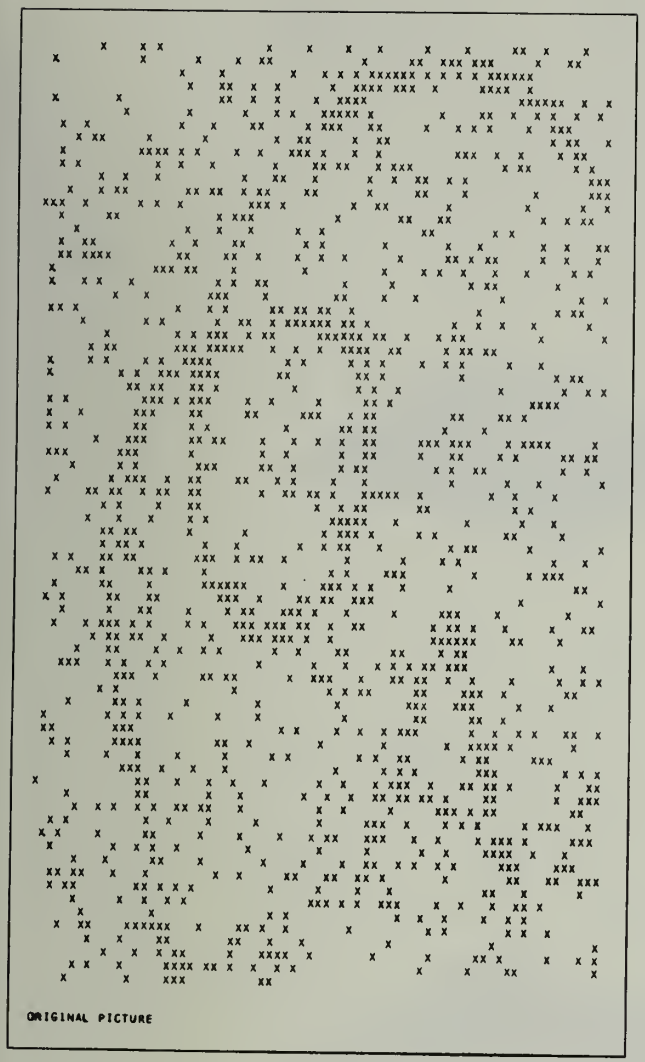
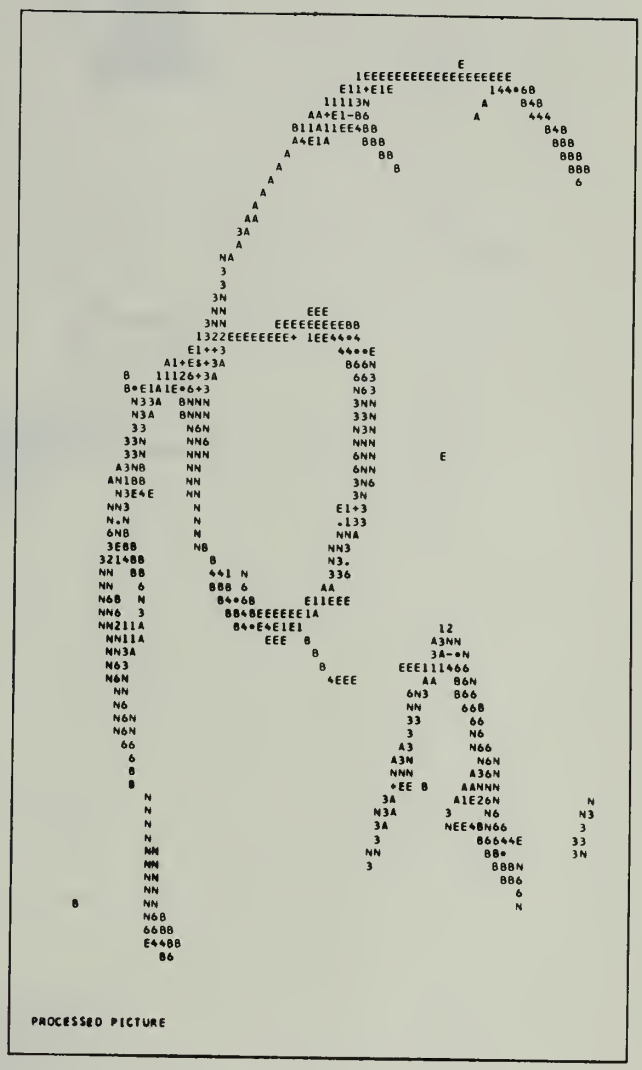


FIGURE I. SCHEMATIC OF ILLIAC III





ORIGINAL

PROCESSED

FIGURE 2. DIGITAL IMAGE FILTERING

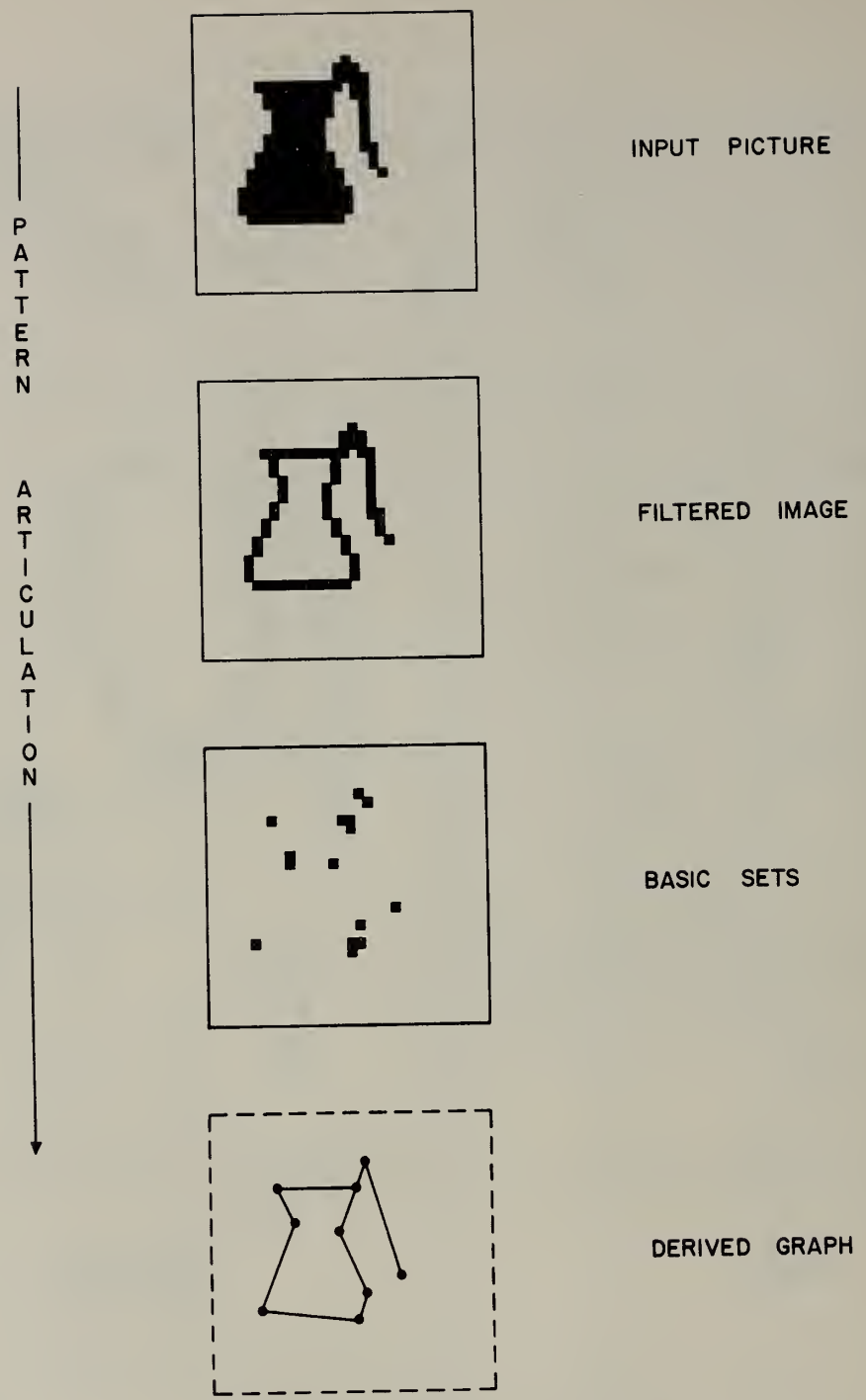


FIGURE 3. VISUAL PATTERN ARTICULATION

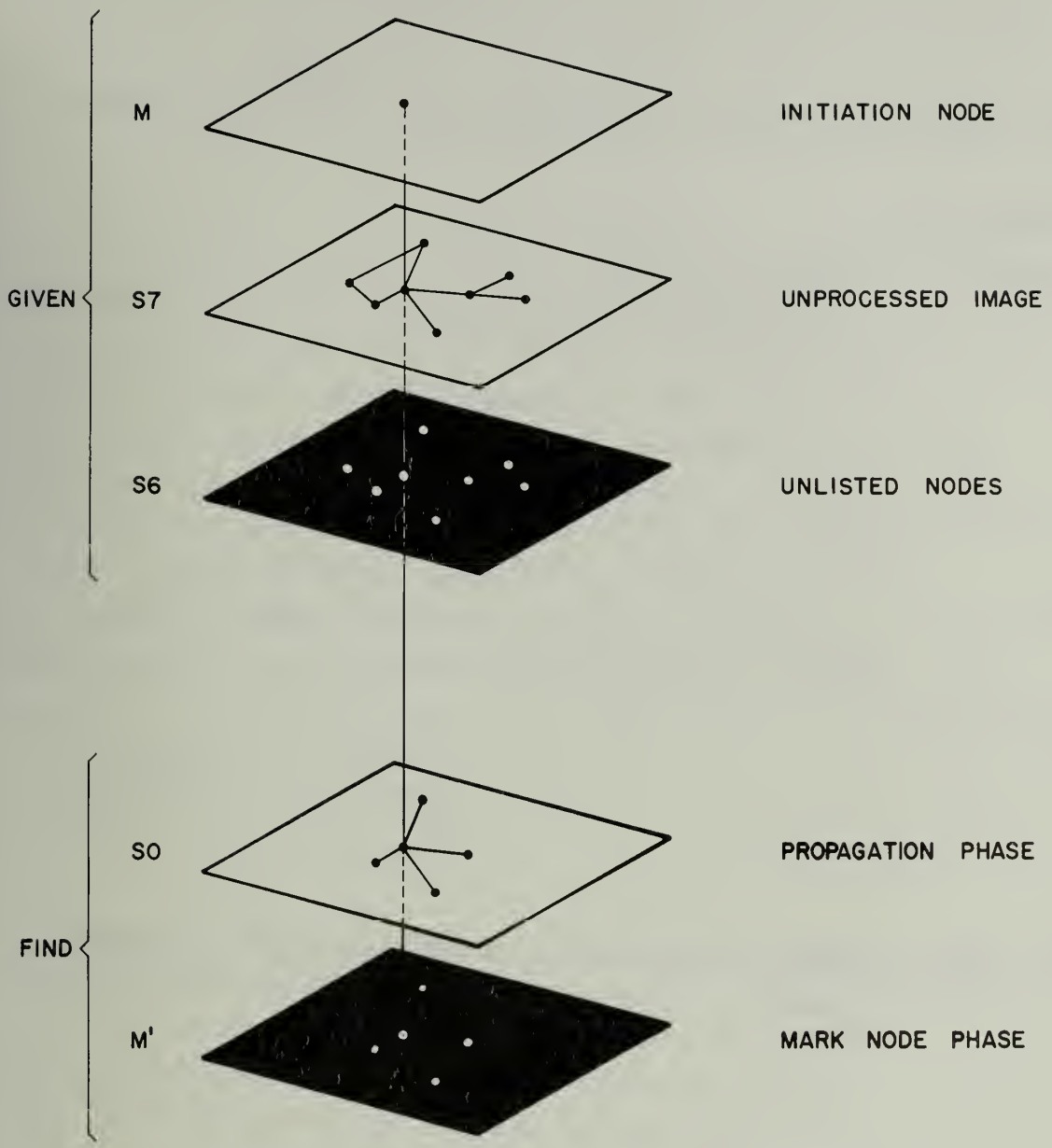


FIGURE 4. ESTABLISHING LINK BETWEEN AN INITIATION NODE AND NEXT NEAREST NODES

(Supported in part by the National Science Foundation under Grant No. NSF-GP-700).

5.1 New Routines

M2-UOI-SPG-66-SR

Manipulation of BCD Strings. This routine converts a string of BCD characters in a given region of core storage according to a format specification and assigns the results of conversion to a given list of variables (storage locations) - entry points SPREAD and FSPRED. It also converts a given list of variables (storage locations) according to a format specification and stores the resulting BCD string in a given region in core storage - entry points GATHER and FGATHR. Spread and GATHER are the entry points for SCATRE and MAD programs; FSPRED and FGATHR are the entry points for FØRTRAN programs.

Programmed by F. H. Westervelt,
University of Michigan
Adapted to the PØRTHØS monitor
and revised by J. K. Moore
February 16, 1965

F4-UOI-SNV1-67-SR

Matrix Inversion with Accompanying Solution of Linear Equations. This subroutine solves the matrix equation $AX = B$, where A is a square coefficient matrix and B is a matrix of constant vectors. A^{-1} is also obtained; indeed, inversion may be the sole aim in a particular usage. The determinant of A is also computed.

Jordan's method is used to reduce a matrix A to the identity matrix I through a succession of elementary transformations: T_n, T_{n-1}, ..., T_1 $A = I$. If these transformations are simultaneously applied to I and to a matrix B of constant vectors, the result is A^{-1} and X where $AX = B$.

Programmed by David Hutchinson
Revised by Eugene Chang
March 22, 1965

C3-UOI-ERF1-68-SR

Floating Point Error Function and Floating Point Frequency Function FØRTRAN, SCATRE, and MAD. For a given floating point argument X this program computes the following quantities:

1) Error function

$$ERF1(X) = \frac{2}{\sqrt{\pi}} \int_{o}^{X} e^{-t^2} \, dt$$

2) Normal frequency function

$$ERF1FR(X) = \frac{2}{\sqrt{\pi}} \int_{-oo}^{X} e^{-t^2/2} \, dt$$

The error function is also known as the error integral, probability integral, or integrale de Gauss.

This routine evolved from 1) University of Michigan Executive System for the IBM 7090 Computer, September, 1963.
2) Hastings, Cecil., Approximations for Digital Computers. Princeton University Press. Princeton, New Jersey, 1955, p. 187.

Modified by F. Benard
March 10, 1965

C3-UOI-ERF2-69-SR

Floating Point Error Function for FØRTRAN, SCATRE, and MAD. This program computes the error function for any given floating point argument X:

$$ERF2(X) = \frac{2}{\sqrt{\pi}} \int_{0}^{X} e^{-t^2} \, dt$$

where ERF2(X) = -ERF2(-X).

This routine evolved from University of Michigan Executive System for the IBM 7090 Computer, September 1963, and Ames Research Center ALERF. Share Distribution 836.

Modified by F. Benard
March 11, 1965

L1-UOI-SVC1-71-SR Write Standard System Records. This routine saves up to ten blocks of the core memory as a Standard Binary System Record on

(a) A specified tape unit.

(b) A specified disk cylinder, or on a specified backup tape (provided one is indicated) if the disk is not available, or if there is a disk failure during the attempt to write the record, or if record is larger than 18640 words.

These records can be reloaded by SYSLSR. If they are written on tape they may also be reloaded by SEQPGM or SELPGM.

Programmed by Freda Fischer
March 25, 1965

L1-UOI-GTLD2-73-SR Call System Loader during Execution Time. GRLD2 has a simpler calling sequence and requires less storage than GTLD1, and should be used for simple load-and-go problems. It will load a program generated either before or during execution from an indicated execution tape and then execute it.

The parameters in the calling sequence are added to the standard loading block used by the Loader, and the Loader is then called into core memory to load and execute the indicated program.

Programmed by Freda Fischer
March 29, 1965

5.2 Problem Specifications

During the first quarter of 1965, 177 problem specifications were submitted to the IBM 7094 for computation. The following brief descriptions of these problems have been prepared for inclusion in this report by those submitting them. T indicates a calculation associated with a theses.

1220-51001 Dean of Students. Interstate Variation in Expenditures for Higher Education. The SSUPAC system will be used primarily for making two variable and multiple variable regression runs to analyze the causes of variation in state expenditures for institutions of higher education. (Paul Magelli)

1221-51002 Civil Engineering. Digital Computer Approach to Problem of Circular Girders. The problem deals with the computation of moment torsion and direct shear at any section of a circular girder. The type of loading can vary from a single load to a limited number of loads that can be used in a 7094. The types of support are also general, in that it may be fixed supports at both ends, pinned, or supports on rollers or any combination of these three. (M. Hassan M. Rejali)

1222-51003 Agricultural Economics. Agricultural Production-Income Potentials. The research problem is to determine desirable adjustments in farm organization for a five county area in Southern Illinois.

Linear programming techniques will be used in determining the optimum use of resources for representative farm situations and in determining minimum resources required for specified levels of net farm income.

The programmed results will be used to determine the implied adjustment potential for the area. (Lyle Fettig)

1223-51004 Chemistry and Chemical Engineering. Crystal Structure of VØPHAC. In order to determine the molecular orientation in the crystal of vanadyl benzyl acctonate the crystal structure of this compound has to be solved. To solve a structure of a crystal the three dimensional summation of the Fourier synthesis will be used. For the refinement of the structure the full matrix least squares method should be employed. Other mathematical methods will also be used in order to get the final results of bond lengths and bond angles among the atoms in the molecule and their standard deviations estimated. (P. K. Hon)

1224-51005 Chemistry and Chemical Engineering. Convective Instability II. This research deals with the stability of a thin, horizontal layer of fluid subjected to the transfer of heat and/or mass and concomitantly a surface tension and/or buoyancy drive mechanism at a planar or tesselated free surface. The IBM 7094 will be used to solve a transcendental equation whose roots are the stability parameters of the system; in turn the stability parameter of the system is a concave function of another parameter, and a Fibonacci search routine is used to find the minimum of the concave curve. (R. L. Sani)

1225-51006 Electrical Engineering. Antenna in Anisotropic Medium. The objective of this research is to determine the antenna behavior in anisotropic medium. Analytically the fields and current of the antenna can be determined by both the eigenfunction expansion and integral transform. Numerically it is necessary to solve a higher transcendental equation (involving Hankel functions) for possible eigenvalues and to evaluate an integral along a branch cut. Library routines required would be Hankel functions of the second kind and of both zeroth and first order for complex argument, and also some quadrature subroutines. (Y. T. Lo)

1226-51007 Bureau of Educational Research. Factor Analytic Studies of School Systems. This problem involves obtaining a least squares solution for the rate of change of expenditure, equipment, etc. over time, and the application of factor analysis to identify a set of variables which best describe the characteristics of various school systems. (William P. McLure)

1227-51008 Nuclear Engineering. Gamma Penetration Moment Calculation. An existing program from the National Bureau of Standards will be adapted to the University of Illinois 7094 digital computer. The program solves the Boltzmann Equation of gamma ray penetration in an infinite medium by the method of moments calculation. (A. B. Chilton)

1228-51009 T Electrical Engineering. Electrostatic Spraying. A computer library program will be used to fit least square polynomials to sets of data relating the charge to mass ratio of electrostatically sprayed glycerine to various parameters.

The library program is Library Routine F4-UOI-LSQ2-32-FR.

(Robert J. Pfeifer)

1229-51010 Industrial Education. Programmed Learning for Teacher Training. This is a study of programmed learning for the State Board of Vocational Education. For the most part, we will use the BORD programs from UCLA which were converted for use on the 7094 by the Bureau of Instructional Research. (Schill)

1230-51011 T Mechanical Engineering. Radiative Heat Exchange. The nature of radiative heat exchange between non-gray, non-diffuse surfaces is being investigated analytically. The object of the calculations is the determination of the local radiant heat flux and the steady state temperature distribution on the surfaces.

The problem can be formulated in terms of two simultaneous equations. The first is a linear integral equation for the radiation intensity leaving a point in the surface. The second relation expresses the conservation of energy at a general point. Once the surface radiation properties are specifed these two equations may be solved utilizing standard numerical integration techniques in conjunction with a method of successive approximations to arrive at the desired results. Experimentally verified expressions for the surface properties will be used and a variety of selected geometries investigated. (A. F. Houchens)

1231-51012 T Mechanical Engineering. Unsteady Heat Transfer in a Radiating Medium. The problem under investigation is the response of a medium (finite and semi-infinite) to a step-change in temperature at one of the boundaries. The medium may transport heat by radiation, or by conduction and radiation or by convection and radiation. The bounding walls may emit and reflect radiation. Depending on the medium and conditions at the wall, the problem leads to the solution of a set of non-linear partial integro-differential equations. In a few cases, under certain simplifying assumptions, these can be combined to yield a single integro-differential equation which is non-linear. It is proposed to use the computer in the solution of these equations. It is contemplated to adopt the method of iteration for the purpose of solution after converting the integro-differential equation to an integral equation. (K. K. Prasad)

1232-51013 T Civil Engineering. Plastic Flow in Elastic-Perfectly Plastic Plates. Plates comprised of an elastic-perfectly plastic material, are subjected to static loads. Initially the plate is elastic; but with increasing load, yielding will begin, which, under further loading will cause the structure to collapse. It is the purpose of this project to study the propagation of yielding in plates with various edge conditions, shapes, and loading patterns. The mathematical formulation of the problem results in non-linear partial differential equations which, at the present time, can be solved only numerically.

A digital simulation technique is employed in which the plate is replaced by a mathematically consistent model. With increased loading the equations governing the model's behavior change, and eventually become ill conditioned. They can be solved, however, by employing a modified Gauss-Seidel procedure. Since each problem will require from 60 to 170 equations to be solved 200 to 300 times, the solution is impossible without the use of a high speed computer. (L. A. Lopez)

1233-51014 Communications. Attitudes in Conflict Situations. This study examines how attitudes and beliefs about a person differs from beliefs about his actions in a conflict situation.

Data are collected by means of a war simulation experiment, in which subjects rated his adversary and his adversary's actions in 12 trials, according to 12 factors on 9-point scales.

The computer will be used to do factor analyses and intercorrelations of factor scores. (M. Dahlan)

1234-51015 T Chemistry and Chemical Engineering. Spin-echo NMR. It is designed to study the chemical exchange processes by the Carr-Purcell nuclear magnetic resonance spin-echo method. The computer programs are used to obtain the best fit values of the exchange rate, of the chemical shift between two sites, and of the transverse relaxation time in the absence of exchange calculated from experimental values of the relaxation time. The statistical errors of these quantities are also determined by the computer programs. (Fu-Ming Chew)

1235-51016 T Chemistry and Chemical Engineering. Chemical Shifts in NMR. The purpose of this problem is to compute nuclear magnetic resonance chemical shifts from atomic and molecular information, and using previously developed formal theory. The problem is divided into two parts. One is computing wave functions from molecular structure data and, perhaps, the results of group theory. The other is to then compute the chemical shifts from the wavefunctions. (Eugene Friedman)

1236-51017 T Mechanical Engineering. Hydrostatic Bearing. The computer will be used to calculate pressure and velocity profiles in hydrostatic gas bearings under various conditions of load, and using various types of bearing lubricants such as dry air, wet air, oil mist, and oil.

Standard library routines will be used. (W. L. Winterbauer)

1237-51018 Aeronautical and Astronautical Engineering. Turbulent Flame Structure and Stability. The Hug Code (for calculating equilibrium composition of ideal gas mixtures for up to 100 species and 6 components; adapted from a code on the 7094 from Los Alamos) will be used to calculate, through an iterative process, the equilibrium composition and temperature of a variety of oxidizer-fuel systems. This work is being conducted under the auspices of a National Science Foundation Grant devoted to the study of the characteristics of premixed fuel-oxidizer flames. (R. A. Strehlow)

1239-51020 Chemistry and Chemical Engineering. X-ray Studies on Organic Molecules. A study is being carried out on the structures of some small, sulfur-containing, organic molecules. It is intended to carry out three-dimensional x-ray analyses on some crystals containing these compounds. For this purpose, a considerable amount of computer time is necessary to compute electron density maps, calculating structure factors to compare with observed data, and using various methods of refinement-analysis. (I. C. Paul)

1240-51022 Psychology. Repression-Sensitization Pilot II. This is a continuation of a pilot study on repression-sensitization. Intercorrelations and odd-even reliabilities are to be computed for seven personality scales. Correlations and odd-even reliabilities will then be computed separately on all variables for repressers and for sensitizers. The hypothesis tested is that sensitizers show greater within-individual variation on these personality measures than do repressers. (Barbara Blaylock)

1241-51023 T Psychology. Questionnaire Assessment of Emotionally Disturbed Parent-Child Relations. This study is an investigation into many facets of emotional disturbance in children. Questionnaire responses of parents of clinic and non-clinic children will be systematically compared on the basis of empirically derived scoring systems. The clinic sample is 180 cases and the non-clinic sample is 700 cases. Each case consists of responses to nine separate questionnaires, some of these questionnaires being composed of as many as 577 items.

The computer will be used to cross validate the empirically derived scoring systems, to evaluate their validity as a discriminator between clinic and non-clinic populations, and to investigate the relationship between parental attitudes and behaviors and resultant emotional disturbance in children. (Ronald S. Krug)

1242-51024 Economics. Consumption Pattern Model. A non linear model including a new idea in determination of consumption demand in the context of long range business cycle determination is presented. The machine is used to determine economic behavior for 76 years including 16 years of past observations which are used as inputs along with the coefficients or parameters of the model. The establishment of parameter relationships affecting the plausible behavior of the model is sought after in order to aid later possible attempts to obtain statistical fits of parameter values to actual observations. An iterative procedure of determining simultaneous levels of key variables is employed in each year. (Leon L. Tucker)

1243-51026 Agricultural Economics. Wabash Basin Program. A linear programming model is being developed to give a first approximation of the likely direction that agricultural resource use will take in the Wabash Basin. This is a minimum-cost model which contains, as alternatives, a number of projects--irrigation, drainage and flood damage. The solutions should give the minimum-cost resource mix required to produce specified quantities of goods. (E. R. Swanson)

1244-51027 T Psychology. Modeling and Nurturance. The primary objective of the proposed research is to assessthe effects of a nurturant interaction with an adult on the imitation behavior of preschool children. In addition, subsidiary problems relating to the childrearing antecedents of imitation behavior will be examined by correlating child experimental measures with parental interviews and questionnaires, naturalistic observations of the subjects, nursery school teacher rankings, and ratings of theoretically important variables. The effects of nurturant manipulations will be examined by the use of two imitation tasks, one focusing on a modeling of novel aggressive behaviors and one on the modeling of a fear or dislike for a particular toy.

Analysis of variance will be performed on the experimental measures. This will involve a three-way analysis of variance, for each dependent variable. Appropriate testing for the relation between preschool dependency behavior and experimental imitation will be determined after examination of main experimental effects and distribution of subjects on dependency relative to experimental groups. Most of this computation will be done with a hand calculator.

The need for a computer arises in analyzing correlations among parental measures derived from questionnaires and interviews and among child measures derived from direct observation and ratings by five observers. Some of these analyses will require factor analysis to reduce the data to summary scores. Other analyses will simply require use of available scoring programs. The computer will also be necessary in relating parent summary measures to assessment of child behavior. (Charles Madsen)

1245-51028 T Chemistry and Chemical Engineering. Chemical Reaction Stability. The problem is to find stability criteria for chemical reaction systems which are described by partial differential equations. Linearization of various parts of the problem results in sets of transcendental equations which will be solved by trial and error techniques. Computations also involve the solution of the partial differential equations of the various transport processes of both the steady state and transient types by various numerical techniques. (David Winegardner)

1246-51029 Department of Computer Science. Complexes of the Lanthanides. It is desired to find the free energy and the enthalpy of formation of complexes of the lanthanides with certain carboxylic acids. In these systems, several complexes coexist in solution; n has a maximum value of 4. The experimental data consists of data on the concentrations of some components of the solution, and calorimetric data. These data are treated by least squares techniques to arrive at the desired parameters ΔF_n and ΔH_n $(n = 1,4)$. (Friedman)

1247-51030 Institute of Communications Research. UN Meaning. Questionnaire data has been gathered from two samples, one a student population and the other from the general population. The questionnaire included an information test on the United Nations, semantic differential ratings of the UN and related institutions and activities, and demographic and political preference data.

The analysis will be in two parts. The first will determine the meaning structure of the UN as related to the knowledge of the UN and other variables. The second will examine the various groups to see if they use the same or different factors of meaning on the institution. (Howard Bobren)

1248-51031 Physics. Rare Earths. To calculate the preferred spin angles for the helical antiferomagnetic phases of the rare earth metals one must minimize the energy due to the spin-spin iterations. This is a simple sum over a few allowed superzone boundaries, but fairly high accuracy is required, for the energy depends only very slightly on the spin angle. (J. L. Beeby)

1249-51032 Mechanical Engineering. Air Conditioning Load Calculation. It is desired to calculate the heat gain of a building on an hourly basis by entering tabular data into the computer and calling for it as needed for calculations. (W. F. Stoecker)

1250-51033 Mechanical Engineering. Emissive Properties of Conductors. One of the most important properites involved with the calculation of radiant heat transfer rates between surfaces is the emissivity. Very few models have been presented for surface emissivity; but in recent years with the increased use of polished metallic surfaces, the predictions of electron magnetic theory have gained considerable importance. The purpose of this research is to study in detail the predictions of the wave theory for the emissivity of electrical conductors. The wave theory predicts the monochromatic directional emissivity and numerical integration is required to calculate the directional emissivity (in integrated even wave length), the monochromatic hemispherical emissivity (integrated over direction), and the total hemispherical emissivity.

Standard numerical integration techniques are required for the calculation of the emissivities. (R. G. Hering)

1251-51034 Mechanical Engineering. Emissive Properties of Nonconductors. The emissivity of a surface participating in radiant heat exchange is one of the most important parameters which influences the radiant heat exchange rates. The wave theory predicts the monochromatic directional emissivity of nonconductors of electricity. As yet, no detailed investigation has been made of the predictions of this theory nor of their validity in light of recent careful experimental measurements. It is the purpose of this research to study the predictions of this theory for the monochromatic directional emissivity and by numerical integration obtain and study the predicted directional emissivity and hemispherical emissivity. Standard numerical integration techniques are required for the calculations. (R. G. Hering)

1252-51035 Mechanical Engineering. Design of Metal Cutting Tools. The initial phase of this project has been limited to single point tools to keep within practical bounds. The list of specifications fed to the program includes those commonly supplied to the tool designer. The program then is mainly concerned with selecting the tool material, the shape of the tool, the tool angles, the chip breaker, and the most economical standard or special tool for the job.

A choice is made from the three most widely used tool materials first on the basis of cutting speed ranges given by published recommendations. The specific grades of tool materials selected then depend upon feed and depth of cut as well as speed.

An alphanumeric system is used to describe precisely all the operations performed by the tools included in this project. A standard tool system like those found in most large plants has been adopted, and a computer table look-up and comparison procedure is used for selecting the proper type of tool for any specified operation within the scope of the project.

Tool angles are determined from a table look-up procedure by the computer to select the best available angles for standard tools for a particular job. In addition optimum rake angles are calculated from theory. Calculations then may be made to ascertain the operation savings that may be expected from using the optimum tool and comparing these savings with the extra cost of a special optimum tool to recommend whether a standard or special tool should be used for the job. (Lloyd Lehn)

1253-51036 Mechanical Engineering. Tool Force and Chip Breaker Analysis. The object of this research is to show that factorial type experimental designs versus the "one variable at a time" type of investigation are more efficient means of collecting and analyzing metal cutting data (in particular; tool force prediction and chip breaker design variables). Factorial experiments will be run to show that a minimum number of data points can be taken to predict the response variables within a practical amount of accuracy.

The computer will be used for:

1. The statistical analysis (multiple regression and analysis of variance) of the experiments.
2. The calculations of the response surface of the dependent variables as functions of the regression equations found in 1 above. (Lloyd Lehn)

1254-51037 T Mechanical Engineering. Cavity Flow. Complex integrals associated with the analysis of flow in cavities will be numerically integrated. (Erv Bales)

1255-51038 WPGU Radio Station. Automated Program Log. The computer will be used to assemble and print a radio station's daily program and commercial log from information inputted on cards. Output will be, depending upon a parameter card, a "programs only" log, a "commercials only" log, or a combination log for the specified day. Also, the following three lists will be assembled and printed by the program for billing purposes: 1) Sponsor number versus time for each commercial scheduled, sorted by time; 2) Sponsor number versus time for each commercial scheduled, sorted by sponsor number; 3) A list of only those sponsors having commercials scheduled on the specified day, and the number of times that each commercial is scheduled to be given.

Any reasonable number of days may be run sequentially if each is preceded by a card containing the date for which the log is specified. This date will appear on each page of the log. (Larry Rosen)

1256-51039 Institute of Communications Research. Presidential Election 1964. This study is a three-wave panel study of the 1964 presidential election. One month before, one week before, and one month following the election, 400 residents of Champaign-Urbana were interviewed in their homes. At each time, all respondents were asked to evaluate 24 issues relevant to the campaign and to indicate where they felt each candidate stood with respect to each issue. In addition, each respondent evaluated each of the candidates and indicated whom they intended to vote for.

The computer will be used to analyze all the data from this study. Specifically, two-mode factor analyses for each time period will be conducted. In addition, predicted and obtained attitude scores will be computed for each subject and then intercorrelated. Further, individual and group means on all issues will be calculated and subjected to analyses of variance. (Fishbein)

1257-51040 Psychology. Congressional 1962. This study is a three-wave panel study of the 1962 Congressional election. One month before, one week before, and one month following the election, 400 residents of Champaign-Urbana were interviewed in their homes. At each time, all respondents were asked to evaluate 21 issues relevant to the campaign and to indicate where they felt each candidate stood with respect to each issue. In addition, each respondent evaluated each of the candidates and indicated whom they intended to vote for.

The computer will be used to analyze all the data from this study. Specifically, two-mode factor analyses for each time period will be conducted. In addition, predicted and obtained attitude scores will be computed for each subject and then intercorrelated. Further, individual and group means on all issues will be calculated and subjected to analyses of variance. (Fishbein)

1258-51041 T Chemistry and Chemical Engineering. Microwave Double Resonance. A microwave double resonance experiment involves radiating one rotational transition with a strong microwave signal and observing its effect by detecting another, weaker, microwave signal. The strong signal produces line shape and population effects which can be calculated by known methods. A Fortran program has been written to calculate these effects on the basis of published work and will be used in testing the generality of the theory for various systems and experimental conditions. (Mark Unland)

1259-4D018 This problem specification was filed wrong so it was typed in the 1964, Fourth Quarter Report as an Instructional Problem. See I0158.

1260-51042 Mechanical Engineering. Thermal Contact Resistance. The computer will be employed for several aspects of this problem: a) data reduction; b) analysis of thermal constriction resistance; c) analysis of thermal elasticity problem. Part 'a' consists of routine algebraic calculations. The computer is employed in order to eliminate many hours of tedious calculations. In parts 'b' and 'c' the differential equations are reduced to difference equations and solved by a Gauss-Seidel iterative procedure or a similar procedure. (A. M. Clausing)

1261-51044 Home Economics. Film Test for Understanding Children's Behavior. Several members of the child development division are working on a film test for understanding children's behavior. There will be some work done on correlating test scores with course grades, correlating, parents'test scores with their children's behavior, and other related work using this test as an assessment of attitudes toward and information about children's behavior. (Phillip O'Neill)

1262-51045 Civil Engineering. Studies of Beam Configurations. The research consists of the study of closed section beams as applied to slab-girder bridges of the composite type. It is intended to study the lateral distribution of loads when closed section beams are used and how it compares with open section beams.

The ultimate aim is to determine the most economical beam cross-section for such bridges. The effect of diaphragms on the behavior will be investigated also. (Sana Abdelsamad)

1263-51046 T Agricultural Economics. VN Economic Plan. Linear programming is to be solved with use of simplex method. In the model, national income is maximized subject to constraints in form of resources endowments. (Luan Chau Tam)

1264-51047 Physiology. Metabolic Mixtures. The Human Environmental Research Laboratory has been awarded a grant from the National Science Foundation to study the differences in the physiological reactions of males and females to hot atmospheres. There are both qualitative and quantitative differences in sweating, metabolism, circulation, thermoregulation, and clinically evaluated heat tolerance. The investigations are designed to establish the major differences and elucidate the mechanisms involved. Detailed analyses of the metabolism are most important in these evaluations. A computer program for calculating the proportion of energy derived from protein, carbohydrate, and fat has been developed and data collected from volunteer subjects will be analyzed by this program. (F. Sargent)

1265-51048 T Electrical Engineering. Surface Wave Excitation. There exists a class of open-boundary structures which are capable of guiding an electromagnetic wave. These structures are capable of supporting a mode (called a surface wave) which is intimately bound to the surface of the structure. This surface wave which corresponds to a discrete eigenvalue solution to the wave equation is characterized by the roots of a transcendental equation.

The electromagnetic fields within various parts of the structure and in the space surrounding the structure can be expressed in terms of a complex integral and in some instances in terms of infinite series. The computer is used to determine the eigenvalues, to obtain field patterns as a function of position, and to calculate other parameters of the structure. (C. Bates)

1266-51049 Astronomy. Stellar Space Velocities. Stellar space velocities are to be computed and the dispersion in velocity determined as a function of stellar abundance.

The first step involves reduction of microphotometer data of stellar spectra, which has been digitized and stored on IBM punch cards. The data consist of calibration information for each photographic plate traced, as well as plate positions and absorption line transmissions. The absorption lines of interest are searched for by the computer; when found, the plate transmissions are converted to relative intensities.

The second phase of the program is the correlation between line strengths and stellar temperatures and luminosities. The data from several hundred "standard" stars, whose temperatures and luminosities are known, is used to formulate the correlations.

In the final phase, luminosities are determined from the spectroscopic data for approximately 1000 "program" stars. This information, coupled with previously determined data, permit calculation of the stellar space velocities. (Kenneth Yoss)

1267-51050 Chemistry and Chemical Engineering. One-Center Calculations. In the calculation of molecular electronic wavefunctions, one generally must do a large number of integrals over the functions in the expansion basis used. These integrals would be much simpler if all the basis functions were one-center, i.e. had their cusps at the same spatial point, rather than being centered on the various

nuclei of the molecule. However, it is difficult to construct a linear combination of these having the cusps which must exist at all the nuclei unless a very large basis set is used. The extra work in doing multi-center integrals is not as serious as the extra work due to a very large basis set, so one-center expansions are comparatively seldom used today for molecular calculations.

A set of functions to be centered on the midpoint of a diatomic molecule have been constructed which would give cusps also at the positions of the nuclei. The form of these functions is not much different from that of the commonly used Slater orbitals, so that the integrals involving them are not very difficult to do, and formulas have already been derived for some of these. Some preliminary calculations on the H_2^+ and H_2 molecules will be performed to see whether ideas about the superiority of these basis functions to others used for these problems will be borne out.

As the formulas for these integrals are quite complicated and take fairly long to evaluate for particular values of the parameters involved, and as it is necessary to perform such evaluations for a series of choices of these parameters according to the variation method, it will be necessary to use the computer. The formulas involve algebraic manipulations, as well as exponentials and such special functions as the exponential integrals. It is anticipated that the programs to evaluate the integrals and carry through the variation of parameters will be short and uncomplicated. (Jerry Goodisman)

1268-51051 T Psychology. Criteria for Farm Managers. Data are ratings on categories of farm manager's behavior, ratings on "schools of thought" concerning success as a farm manager, farm records, aptitude test scores, vocational interest measures, and biographical information on recordkeeping-owner-operator farmers in Illinois. Most of these variables can be considered as either predictor or criterion information. The relationships between and within sets of the variables will be analyzed using canonical and factor analytic methods. (Alfred B. Carlson)

1269-51054 Civil Engineering. Analysis of Gamma Ray Density Apparatus. The apparatus will be experimentally calibrated by finding the values of 2 dependent parameters at various values of 4 independent parameters. Past experience has shown that the dependent parameters are constant over a limited range; this hypothesis will be tested using statistical methods.

The relative contributions of the once-scattered, twice-scattered and more scattered radiation will be computed by integrating the relevant differentail equations, if necessary by Monte Carlo methods. The results will then be related to the experimental data so as to provide understanding of the method, particularly the distribution of radiation within the tested specimen. (Preiss)

1270-51055 Agronomy. Nitrogen Metabolism in Zea mays. Seasonal patterns of nitrate reductase activity, nitrate content, and protein are being studied in several corn hybrids and inbreds. The influence of rate of planting and date of planting on these patterns are being studied.

The computer will be used to convert the data to meaningful values. It will then be used to analyze the data for significant differences. It is desired to make single degree of freedom comparisons to determine if significant differences exist among the various treatments. It will be determined if heterosis exists (i.e. is the hybrid higher than its inbred parents?). (Liu)

1271-51056 Agronomy. Forage Evaluation with Sheep. Data from digestion trials with sheep to evaluate experimental forages are to be analyzed by the method of least squares. (H. W. Norton)

1272-51057 Electrical Engineering. Distribution Function Calculation. The problem is to calculate the distribution function for electrons in the atmosphere in the presence of high electric fields taking into account inelastic collisions. (J. H. Cahn)

1273-51059 Agricultural Economics. Illini Egg Handler Simulation-Version 2. The Illini Egg Handler Simulation Version 2 is a business management game. The computer program consists of equations representative of the marketing functions of procurement, processing, distribution and selling. Schedules of demand and price relationships as well as coefficients for the effects of advertising are an integral part of the simulation.

The program was designed as a tool to teach management principles as a part of the department's continuing education program. The computer is used to make the calculations and to print out financial statements. (R.P. Bentz)

1274-51061 Education. Research In Education. The investigation of variables associated with learning, such as response latency, aptitude, review techniques, etc. is intended. The computer will be used mainly for data analysis such as analysis of variance and covariance, factor analysis, correlations, etc. (L. M. Stolurow)

1275-51063 Horticulture. Rate of Development of Sweet Corn. The purpose of this problem is to develop mathematical equations in which morphological characteristics are used to measure the amount of development in sweet corn. Standard multiple regression programs currently available will be utilized in developing the equations. (Arnold)

1276-51064 Chemistry and Chemical Engineering. Spectroscopic Analysis. This problem involves the calculation of the wavelength in air, wavelength in vacuum and the reciprocal wavelength in vacuum for each line observed in atomic and molecular spectra recorded on a photographic emulsion. The input data include the accurately measured position (in mm.) and the identification for each line. The calculations represent a least squares determination of the dispersion formula based on measurements of fiduciary lines included in the spectra. A choice of either a straight line or a parabola may be used for the dispersion relationship.

Where necessary, the index of refraction of air is calculated according to Edlen's formula using an iterative procedure.

The spectra are recorded during flash photolysis or flash heating processes in which it is desired to identify and study certain free radicals or other very reactive chemical species produced. (Jack G. Kay)

1277-51067 Mechanical Engineering. Turbulent Particle Motion. An analysis is to be made for the important parameters which govern the turbulent transport behavior of small particles in dilute suspension under restrictive conditions. The Lagrangian equation of particle motion is treated as a linear, stochastic integro-differential equation to which the Fourier transform is applied. Expressions are obtained which relate the intensity, energy spectrum, double velocity correlation coefficient, etc. of the two phases. A measure is proposed to describe the degree of departure of the particle motion from that of the fluid. The computer will be used to process experimental data currently being obtained from the Lintronics hot-film anemometer. It is anticipated that within one month it will be possible to take Lagrangian turbulence data for the particle motion using a home-built photo-multilier tracking facility. (B. T. Chao)

1278-51068 T Psychology. Dimensionality and Simple Structure. The effect of dimensionality (No. of factors) on the determination of simple structure by rotation to maximum hyperplane count is to be investigated for

(a) artificial data (Cattell-Dickman Ball Problem, Cattel Plasmode), and

(b) real data with well established factor structure.

For each set of data the SSUPAC system will be used to derive factor matrices (iterating for communalities) for a varying number of extracted factors. The MAXPLANE program will be used to rotate each of these factor matrices to simple structure.

These results will be used

(i) to study the effect of incorrectly estimating the number of factors,

(ii) to examine the process of factor-fission and factor collapse, and

(iii) to evaluate the amount of hyperplane blurring (the width of the hyperplane) caused by reduced dimensionality. (M. Coulter)

1279-51069 State Water Survey. Hot Wire Analysis. Aircraft oscillograph recordings of atmospheric potential gradient, space charge, temperature, relative humidity, and pressure are determined as functions of space and time. The location of the aircraft with reference to a cartesian coordinate system as a function of time is computed from airspeed and heading data. The magnitude of perturbations caused by a ground source of space charge released into the atmosphere is determined. The effects of the space charge on the development of clouds will be studied by means of the computer output data. (R. G. Semonin)

1280-51073 State Water Survey. Droplet Growth Rate. To determine the rate at which a droplet will grow in size as it falls through a cloud of droplets of a given size distribution, it is necessary to solve an integral equation by the use of a computer. The various parameters for droplet pairs which are needed for solving the equation of growth will be supplied by data cards. (R.G. Semonin)

1281-51074 State Water Survey. Particle Collision Efficiency. Trajectories of one sphere relative to a second sphere is a viscous medium with electrostatic forces present are to be computed by solving the differential equations of motion for the sphere. The program will require only the physical parameters of the system in order to determine the initial conditions which result in collisions and determination of the collision efficiency of a given pair of spheres. (R. G. Semonin)

1282-51076 Physics. Local Mode Vibrations. The computer will be used to calculate the amplitudes of vibrations at localized impurities in crystals. The method of Lifshitz will be used in conjunction with lattice models of other investigators. The data will be used for the U center in particular. (Timusk)

1283-51077 Psychology. Cognitive Development. This research problem deals with cognitive development in children, and includes data from learning and problem solving tasks at a number of age levels. The computer will be used for complex analyses of variance, factor analyses, and analyses of covariance. One of the prime uses of the computer, however, will be an analysis of problem solving data which will include as a basic analysis the calculation of sequential dependencies of up to length 10. This analysis will permit an exact specification of the amount of redundancy in subjects' series of responses. (Morton Weir)

1284-51078 Animal Science. Sheep Fertility. Ewes have been given various treatments to control the time of ovulation and then these ewes have been mated to specific rams. The question to be answered is whether certain treatments or rams influence the level of fertility. The method of least squares will be used. (Philip Dsiuk)

1285-51079 Agricultural Economics. Rural Migrant Job Seekers. The problem requires the determination of the success with which rural migrants in the St. Louis area have been able to secure jobs, and what differentials there are based on education, age, marital status, achievement test scores, and other variables. Frequency distributions based on the punch card tabulations are needed to see how the sample is distributed by age, education, etc. Then the data will be examined to get whatever statistically significant differences there are in, for example, achievement and success in keeping a job on the part of those in different age groups, educational classes (schooling) and marital status groups. (Lindstrom)

1286-52004 Soil Conservation. Hydrologic, Hydraulic and Economic Analysis of Watersheds. Using Manning's Formula to determine hydraulic properites of a stream outlet for a watershed, and using the convex coefficient method of flood routing for various frequency storms, and by converting rainfall into runoff using infiltration rates for various soils, the output is reentered into another program for an economic analysis of the present and future conditions. (SCS USDA WRBPS)

1287-52006 T Department of Computer Science. Pattern Description Language. A pattern description language has been devised which may be used for the descriptions of a class of straight line pictures. Such pictures are commonly constructed by digital drafting devices.

The computer will be used in three ways. First, a set of permissible strings will be generated by repeated application of the grammatical rules. Secondly, description strings will be given which must then be plotted by the computer. Finally, a set of pictures will be given from which string representations must be derived. (K. J. Breeding)

1288-52007 T Sociology. Police Disposition Decisions. The primary focus of this research entails a comprehensive study of the nature and determinants of disposition decisions made by juvenile police. The computer is to be utilized in the preparation and analysis of data from tape and/or cards. (Bordua)

1289-52008 Bureau of Business and Economic Research. Validation Study. The nature of the problem is to study various hypotheses on consumer savings and to interrogate response errors on a stratified sample of over 1000 households. The computer will primarily be used for getting multiple regression estimates and various k-class estimates. (R. Ferber)

1290-52010 Chemistry and Chemical Engineering. Crystal Structure Analysis. X-ray crystal structures will be determined using a non-linear least squares program, Fourier analysis, and other programs for correction and analysis of data. All have been written and tested. (Michael Schweider)

1291-52011 Horticulture. Genotypic Influences on Sweetcorn Characteristics. Q-type correlations are to be calculated for approximately 50 sweet corn inbreds with measurements made on 93 characteristics for each inbred. In addition the Q-correlations will be subjected to one or more methods of cluster analysis in order to find sets of closely related inbreds. A program for computing the correlation coefficients is available, and Fortran programs will be written to perform the cluster analyses. (Rhodes)

1292-52012 Institute of Labor and Industrial Relations. Study of Wage Changes. The data show wage changes (rate) by industry, area and year, and it is desired to know the influence of these factors on wages. This is not causal relation analysis, and will not require multiple regression analysis. Simple correlation coefficients include the effect of other variables on particular variables. So only partial correlation coefficients will be needed. (Sano)

1293-52014 T Civil Engineering. A General Formulation of the Elastic-plastic Analysis of Space Frameworks. The problem under consideration is that of an elastic-plastic space frame under specified loading sets, where the load components have fixed ratios to each other. The loads are increased to their largest possible value, and the behavior of the structure is analyzed. The conditions for yielding at a point in a member will be set up, and the effect

of yielding on the member stiffness matrix will be studied. It will be attempted to modify the inverse of the original structures stiffness matrix, instead of modifying the original matrix and re-inverting. The procedure will be designed to be applicable to both instantaneous and incremental collapse. The computer will be used for the various matrix operations, i.e., multiplication, addition, inversion, etc., which are involved. (K. E. Bruinette)

1294-52016 Biophysics. Correction of Distribution Functions. In a study of tissue cell size distributions it is necessary to correct the experimentally observed distributions for fragments of cells produced during sectioning. This program accepts experimental data on cell sizes from a given tissue section, sorts them into size intervals, and proceeds with a step wise method of adjustment of the distribution as follows:

The fraction of cells in the ith size range (diameters D_i to D_{i+1}) which contribute fragments to a smaller size interval (D_j to D_{j+1}) is given by:

$$F = \frac{1}{2L}\left[\frac{D_{2+1}\left(\sqrt{D_{2+1}^2 - D_j^2} - \sqrt{D_{2+1}^2 - D_{j+1}^2}\right) - D_i\left(\sqrt{D_i^2 - D_i^2} - \sqrt{D_i^2 - D_{j+1}^2}\right)}{1} - \right.$$

$$\left. \frac{D_j^2}{D_{2+1} - D_i} \log_e \frac{D_{i+1} + \sqrt{D_{i+1}^2 - D_j^2}}{D_i + \sqrt{D_i^2 - D_j^2}} + \frac{D_{j+1}^2}{D_{i+1} - D_i} \log_e \frac{D_{i+1} + \sqrt{D_{i+1}^2 - D_{j+1}^2}}{D_i + \sqrt{D_i^2 - D_{j+1}^2}} \right]$$

where L is the section thickness.

Beginning with the interval representing the largest cells, this expression is used to remove from each smaller interval the number contributed by fragments of the larger cells. (Jeannine Leichner)

1295-52017 Psychology. Mean and Variance from Frequencies. This problem consists in the calculation of the mean, variance, standard deviations, and standard error of the mean of grouped frequency distributions. These computations are to be made for distributions of males, females, and both sexes combined. (George Ksander)

1296-52019 T Physics. Anisotropy Integrals. The research subject under examination is the angular dependence of the superconducting energy gap parameter. The immediate problem is to infer from the results of certain experiments the anisotropy of this energy gap parameter for various metals. To do this, it is necessary to assume an angular dependence of the gap parameter, insert it into the theoretical expressions for the measurable quantities, compare with the experimental results, and after various parameters until agreement is obtained. Computer time is requested in order to perform the angular integrals involved, since they are to lengthy for hand calculation..

Straightforward use of MAD and available library subroutines will be made in the performance of the angular integrations and the related algebraic manipulations. (John Clem)

1297-52020 Electrical Engineering. Electron Temperature. Current ideas indicate that electrons conduct heat in the ionosphere from the F-region downwards to the E-region. The problem on hand is to investigate the electron temperature profile in the E-region and study its dependence on related parameters assuming thermal equilibrium conditions to exist. The digital computer will be used to solve a non-linear integro-differential equation involved in the study. (Paramasivaiah)

1298-52021 T Nuclear Engineering. Fission Beta Spectrum. This research problem is concerned with the experimental measurement of the time-dependent beta spectrum from the fission fragments produced in the thermal fission of Uranium-235. The computer will be used in the analysis of the experimental data, and to perform some numerical integrations. (J. W. Kutcher)

1299-52022 Economics. Econometric Model of U.S. The problem is concerned with developing an analytical framework for the analysis of economic expenditure and tax decisions made by governmental units in such a way that hypotheses are imbedded in certain equations of a simultaneous equation system. The simultaneous equation system constitutes an econometric model of the

United States in which government is treated as endogenous. Full information maximum likelihood estimates of the parameters have been computed using data for the United States for the 1929-1964 period.

Although certain portions of the remaining work have been completed elsewhere, the remaining computer work involves completion of one stage least squares and limited information maximum likelihood econometric estimates on the same set of 13 equations for purposes of some additional exploration and comparison with the full information maximum likelihood results. It is also desired to complete two stage least squares estimates on a remaining recursive block of three equations. (Walter W. McMahon)

1300-52024 Psychology. Complex Skill Learning. The problem requires the analysis of motor skill learning data by resolution of the data into the component parts by means of extracting the principal roots and vectors from the matrices of cross-products. (C. L. Hulin)

1301-52025 T Industrial Administration. Executive's Value Structures. The problem is an investigation of the personal value structures of business managers and executives. The relationship between personal values and business decisions is studied, as well as that between values and various demographic characteristics (e.g. Hierarchical position).

A value scale has been developed for the study which consists of a twelve scale semantic differential analysis of each of forty value concepts. The value concepts are drawn from Spranger's Types of Men. The value scale judgments are related a ranking of corporate goals and a ranking of personal goals. The values of managers are related to their high rated subordinates and to their low rated subordinates. A three mode factor analysis ($40 \times 12 \times 300$) will be made. (Senger)

1302-52026 T Civil Engineering. Ultimate Strength of Columns Under Biaxial Bending. The problem consists in determining the ultimate strength of steel columnsunder biaxially eccentric load. The analysis includes the effect of torsion and residual stresses.

A complete load-deformation response of the column is obtained by investigating its equilibrium conditions at the midlength. The equilibrium equations thus established for various patterns of yielding are solved by iteration. The procedure is continued till its peak of the curve is obtained. This defines the ultimate load of the column. The interaction curves are then obtained for various values of the eccentricity ratios and the slenderness ratios. (Satya Sagar Sharma)

1303-52027 Dairy Science. Genetic and Statistical Research. The computer time requested is to be used by the Genetics Division of the Dairy Science Department. The primary use of this time will be for exploratory program writing in an attempt to expand the Division's program and subroutine libraries. Tentatively these programs are for the analysis of data using general statistical analyses which are most commonly used in this Division's research. (R. W. Touchberry)

1304-52032 T Civil Engineering. Dynamic Analysis of Multistory Rigid-Frame Buildings Subjected to Lateral Loads. This study will be devoted to developing a method of dynamic analysis for multistory buildings subjected to lateral loads and to using the method to analyze a representative number of structures to determine the effects of parameter variations.

STRESS will be used to generate the lateral flexibility matrix. The flexibility matrix will be inverted to obtain the stiffness matrix and the eigenvalues and eigenvectors will be determined. A set of equivalent static forces will be determined for each mode of vibration and used to calculate the member forces in each mode (using STRESS). The probable force in a given member will be computed as the square root of the sum of the squares of the force in the member (in each mode) times the modal participation factor. (D. N. Burgess)

1305-52035 T Psychology. Determination of Response Curves in Binocular Rivalry. The Tucker method of determining response curves for individuals by factor analytic techniques will be utilized for data on binocular rivalry, a perceptual phenomenon, under 12 conditions of luminance and 3 instructional

conditions. The method involves principal axis factoring of a cross-product matrix and computation of individual factor scores. The method will be applied to two cross-product matrices: (1) a light condition matrix formed by cross-products between individuals over light (luminance) conditions (2) an order matrix formed by cross-products between individuals over the order of light conditions. Both matrices will be 12 × 12 - the raw data matrix is 60 × 12. In addition, variance - covariance matrices and, possibly, correlation matrices will be computed. (Connie Meredith)

1306-52042 T Education. Relation of Administrative Effectiveness To Patterns of Teacher Organization. The problem of this study is to examine teachers' perceptions of the operation of a number of principles of secondary school administration. An attempt will be made to determine whether these principles are more operative in schools with or without teacher welfare oriented formal organizations and whether there is any difference between the union and local association type of organization in this respect.

The basic instrument is a questionnaire to which teachers respond on the basis of their perceptions of practices in effect. Four different teacher groups representing four different conditions of welfare organization have responded. From the computer procedures we expect to get frequency of response counts for each of 100 items, total frequencies for grouped items according to principles, frequency distribution analysis for each of the test conditions, t test for significance of difference between test conditions, and biserial correlations between the test conditions as dichotomous variables and the continuous variable of total yes responses on each of the 15 principles of administration.

The instrument is basically unidimensional and the pattern of research is to test the null hypothesis of no significant difference between effectiveness in operation of administrative principles. (Cox)

1307-52045 Nuclear Engineering. Neutron Attenuation. This problem involves the calculation of dose attenuation in infinite slabs and semi-infinite media. The media are irratiated with neutron sources of various descriptions according to angular and energy dependence. The computer will be used for cross-section averaging and in the later stages of the problem will be used possibly for "Moment Method" and "Monte-Carlo" calculations.

When the semi-infinite medium dose attenuation is obtained, the problem will be repeated with various cavity shapes (representing shelter areas) present below the surface. (A. B. Chilton)

1308-52046 Agricultural Engineering. Dynamics of Machines. Several problems dealing with dynamics of particles and machine elements will be investigated for research and for toturo inclusion in senior level and graduate courses. In most instances solutions of single (or systems of) differential equations, both linear and nonlinear, will be involved. (Roger Yoerger)

1309-52047 Forestry. Moist Stress and Tree Growth. It is desired to determine the effects of controlled soil moisture stress on (1) foliar nutrients, number of growth flushes, diameter growth, and height growth of loblolly pine trees; (2) the specific gravity, tracheid length, and percentage of late wood, early wood, cellulose, extractives, and lignin of the wood of loblolly pine trees. (A. R. Gilmore)

1310-52036 Mathematics. Finite Group Computations. Programs will be prepared to aid in investigations in the area of finite groups as follows.

1. Todd-Coxeter method for computation of the order of a finite group from generators and relations (where feasible). The programs will be done in Nicap to utilize the advanced control and quarter word features of Illiac II as fully as possible. One program will handle groups given by two generators, a second will handle groups given on four generators.
2. The new simple group of Zvonomir Janko will be investigated. The presentation by matrices over GF-11 will be converted to a group presentation in terms of generators and relations by computing the orders of certain words on the matrix generators given by Janko. Various further properties of this group will be studied by actual exhaustive computation. (K. Appel)

1311-52048 T Dairy Science. Specific Combining Ability in Dairy Cattle. Lactation records from the Dairy Herd Improvement Association of the U.S.D.A. will be used to estimate specific combining abilities among dairy cattle. Three measures of specific combining ability will be used: (1) component of variance analysis of sire by grand-sire interaction using lactation records expressed as deviations from contemporaries; (2) analysis of the within-subclass transformed variances; (3) deviation from the computed expected producing ability of each subclass.

The computer will be used to perform the statistical analysis. Henderson's method 3 for component of variance analysis will be used. (R. G. Peterson)

1312-52049 T Theoretical and Applied Mechanics. Shear Stress Distribution in Elastic Plates. This investigation is an attempt to determine the distribution of the transverse shearing stresses in a simply-supported, uniformly loaded, rectangular elastic plate using a theory developed by Reissner. The analytical solution that has been obtained is in the form of a double infinite series. The computer will be used to evaluate the series. (T.G. Carley)

1313-52050 T Civil Engineering. Stress Analysis of an Elastic-Plastic Medium. The object of the study is to develop a numerical procedure for analyzing stresses and strains in an elastic-plastic medium subjected to static loads. Plane strain conditions will be assumed. The medium will be simulated by an assembly of triangular finite elements in each of which the state of stress is homogeneous. Below yield it will be assumed that the elements are linearly elastic. At yield the elastic-plastic response will be governed by the stress-strain relations derived from the yield condition.

The procedure will be applied, in particular, to the study of stresses and strains around underground openings in rock under sufficiently general boundary conditions of practical interest. Stages of enlargement of the opening will be simulated in the model by removal of corresponding elements. At each stage the response of the rock mass will be determined.

The computational procedure will entail the solution of large systems of equations. In general this will be done by iteration. Using the stiffness method of structural analysis a compatible trial displacement pattern can be calculated from the boundary loads. If the response is purely elastic this displacement pattern is the correct one. If yielding occurs in some of the elements, further trials will have to be made until equilibrium conditions are satisfied. (S. F. Reyes)

1314-52051 Bureau of Economic and Business Research. Trip. The problem concerns an analysis of surveys to determine the possibility of improvements of bus transportation in Peoria Illinois. Tables for analysis (cross tabulation and frequency counts) are needed. (Michael Blurton)

1315-52054 T Chemistry and Chemical Engineering. Triple Label Analysis. The research problem is to characterize changes in the ribonucleic acids of cells during differentiation. Radioactive labeling of the various types of ribonucleic acids will be used as an aid to the characterization. The computer will be used to analyze the data from triple label experiments and to display the data on a cathode ray tube for photographing. The mathematical operations are standard library routines of addition, subtraction, multiplications, divisions, and data displays. (Charles Hosler)

1316-52057 Medical Research Laboratory. Tumors and Viruses in Germ-Free Mice. Two series of experiments are being conducted in which the susceptibility of germ-free mice is being compared with the susceptibility of conventional mice to viruses (myxoviruses and oncogenic viruses) and to transplantable tumor cells of various established tumors.

Some of the parameters of susceptbility being recorded are time to death, time to onset of illness, levels of specific antibodies produced, tumor size on specific dates and the number of animals which show these effects. Records of these parameters will be analyzed for significant differences. (F. R. Watson)

1317-52058 Psychology. Factor Analysis Methodology. The present problem was designed to investigate procedures involved in factor analysis. The problem will require routines for a computation normally available in the Fortran and SSUPAC systems. (William M. Erwin)

1318-52059 Ceramic Engineering. Lattice Parameter Determination of β-Spodumene. The determinations are made by use of the relation between the crystalline cell edges and the "d" spacings obtained from x-ray powder patterns. Mathematically the relation is

$$\frac{1}{d_{hkl}^2} = \frac{h^2 + k^2}{a^2} + \frac{l^2}{c^2}$$

(for a tetragonal crystal) where a and c are the lattice parameters; d_{hkl} is the spacing for the hkl line; and h, k and l are the Miller indices. An assumed a/c ratio is initially made and then the method of least-squares is used to obtain the "a" parameter and the a/c ratio at a diffraction angle of 90°. The lattice determinations were made for slightly altered synthetic β-Spodumene and also for relatively pure β-Spodumene at temperatues up to 900°C. (Martin Lawrence)

1319-52060 Chemistry and Chemical Engineering. Overlap Integrals of Group 0 Crystals. Overlap integrals for some outer shell, outer-inner shell wave functions will be calculated for normal crystal configurations of the Group 0 elements. (J. D. Allen)

1320-52061 Economics. Production Functions. SSUPAC to be used for estimating a variety of aggregate production functions. (D. J. Aigner)

1321-52062 T Chemistry and Chemical Engineering. Transient Melting and Freezing of Soups. The differential equations to be solved are

$$\frac{\gamma T_1}{\gamma t} = \gamma_1 \frac{\gamma^2 T_1}{\gamma x^2}$$

$$\frac{\gamma T_2}{\gamma t} = \gamma_2 \frac{\gamma^2 T_2}{\gamma x^2}$$

with the following boundary and initial conditions

$$LP \frac{de}{dt} = k_1 \frac{\gamma^{T_1}}{\gamma x}\Big|_{x=e} - k_2 \frac{\gamma^{T_2}}{\gamma x}\Big|_{x=e}$$

$$T_1(e,t) = T_c(e,t) = T_F$$

$$\frac{T_1(x,o) - To}{Ta-To} = 1 - e^{-kt}$$

$$T_2(x,E) = T_b$$

$$T_1(x,o) = T_a^1 + \frac{g}{k_1} x$$

$$T_2(x,o) = T_F + \frac{g}{k_2} (x - e)$$

Two numerical techniques are to be employed. One is an explicit method utilizing a forward difference on time and a central difference on distance. The other is an implicit technique using a forward difference in time and the Laasonen four-point difference for distance. Both techniques utilize a variable space network. (David Boger)

1322-52063 T Theoretical and Applied Mechanics. Creep Analysis of Portal Frames. The problem to be solved is a creep analysis of statically indeterminate portal frames, based upon the arc hyperbolic sine theory. The type of loading will be a proportionate loading and a stepped load history.

Two methods will be used to predict the load-deformation behavior of the portal frames--the Energy method and the Deformation method.

Three cases of statically indeterminate portal frames will be studied: frames with one, two and three redundancies.

Portal frame with one redundance. The dimensionless coefficient α of the redundant reaction is a function of the magnitude of the load W, since the moment-curvature relation is nonlinear in case of creep. A family of curves is involved in representing the relations between the deformation at the section where the restraint is being removed temporarily, the dimensionless coefficient α and the magnitude of the load W. The problem is to find the appropriate value of α corresponding to a given W, such that the deformation equals zero.

Portal frame with two redundancies. The dimensionless coefficient for the redundant reactions are α and β. The relations between the deformations, dimensionless coefficients and the magnitude of the load W can be represented by 2 sets of families of curves. Of importance is to find the values of α and β for a given W, such that the deformations (at the section where the restraint is being removed temporarily) are equal to zero.

Portal frame with three redundancies. α, β and γ are dimensionless coefficients for the redundant reactions. Three sets of families of curves will represent the relations between the deformations, coefficients and W. The appropriate values of α, β and γ should be found.

The IBM 7094 will be used to solve for the above.

(Sosrodiningrat)

1323-52064 T Civil Engineering. A Probabilistic Model for Earthquake Type Distrubances. In the probabilistic study of earthquake effects on structures, it is necessary to represent the ground acceleration by a random function of time. The idealized functions proposed thus far are at variance with one another and bear almost no resemblance to existing earthquake records. It is therefore proposed to study some 24 existing earthquake records already digitized and balanced for this program, for the fundamental assumptions of randomness and normality, to compute some reliable statistics such as mean value, variance, and covariance functions from the records, and on the basis of this information to propose a better idealization for ground acceleration during earthquakes. (M. Amin)

1324-52065 T Botany. Apocynum Species I. The plant genus Apocynum is restricted approximately to the United States and Canada. It has been the subject of descriptions of about 180 species, subspecies and varieties over the last century. In the last thirty years, common consent has reduced their number to about a dozen species and varieties; some of these, however, being very poorly circumscribed and barely typified.

In the present study, extensive collections have been made of populations throughout North America. These plants have been carefully studied and their morphological characters reduced to either measurements of parts or numerical values corresponding to degree of expression of a subjectively expressed character. It is hoped that use of a multiple correlation program will enable these characters to be compared in several ways: First, to determine how much variation may be expected within a group of plants known to be genetically identical; second, to compare similarly plants from single, isolated populations which are thought on other bases to represent single "good" species; finally, to compare plants collected at random from other natural populations, some containing more than one visible type of plant.

If the study is successful, it will represent the first real breakthrough in objective characterization of the nature of the difference between biological species, at least in this one case. Extension of the general method to other genera and species of living organisms could give us a valuable tool with which to study evolutionary trends and might enable one to solve many existing taxonomic and evolutionary problems of long standing. (Harold Balbach)

1325-52066 Social Work. Expert Responses. The overall purpose of the project is to determine whether the nonprofessional social worker can be trained by means of the short term training methods demonstrated here, to perform adequately in the licensing of family foster homes. In order to define adequate functioning, an absolute standard was evolved on the basis of the opinions of experts in this field of social work. This has been accomplished by using factor analytic techniques on these expert responses. The computer will also be necessary for the application of this standard to the performance scores of the social workers who have participated in the training program. (Ellen Handler)

1326-52068 Psychology. Motivation Research Analysis. The study is an investigation of motivational influences in behavior using a multivariate experimental design. Computer usage is required for: (a) intercorrelation and factor analysis of a P-technique study with 20 variables on 120 occasions; (b) preliminary recoding and intercorrelation on approximately 150 subjects (animal) on 100 variables, with replication; (c) factorial resolution of two 100 × 100 matrices including rotation to simple structure and the extraction of higher order factors; (d) inclusion in the above of experimentally manipulated variables via Dwyer extension method and/or an analysis of variance design. (J. Weiffenbach)

1327-52070 Psychology. Elation Depression Study. This is a study of the depression factors as they are found in normal subjects. The results will be compared with those from an earlier research which used mental hospital patients as subjects. Each subjects has two scores on each of the fourteen factors of the High School Personality Questionaire and scores from a 236 item depression questionaire. These data will be factored and then rotated to simple structure via SSUPAC programs (principal axes factor analysis, varimax, oblimax, rotoplot). If blind rotation locates factors equivalent to those found with depressed mental patients, new insight will have been gained in knowledge of differences between normal, neurotic, and psychotic depression. (M. R. Blood)

1328-52071 Nuclear Engineering. Fission Electric. The "Fission Electric" cell is a device for the direct conversion of nuclear to electrical energy without a heat cycle. The numerical calculations covered by this problem have two objectives: (a) calculation of the energy spectrum of fission fragments emerging from a thin (< 10 micron) film of UO_2; (b) calculation of the efficiency of a parallel plate cell including a detailed description of the fission fragment energy-charge model and the fission spectrum. The key point of the calculations is the evaluation of four integrals, two of which are single integrals; one double, and one a triple integral. SIMN will be used for the single integrals; a special subroutine is to be written for the others. (G. H. Miley)

1329-52073 Mechanical Engineering. Heating With a Solar-Earth Heat Pump. The digital computer is being used to perform a large number of calculations. The results of these calculations will determine whether or not it is feasible to use solar energy for heating purposes for any specific location. The mathematical methods employed include polynomial curve fit by least-square approximations, and single and double interpolation. (Robert Graven)

1330-52074 Psychology. Transition Probabilities 2. The data to be analyzed are individual protocols from two-choice learning situations. Each protocol consists of 101 successive trials for which the four combinations of choice (correct or incorrect) and reinforcement (reward or no reward) are listed in a 1, 2, 3, 4 code.

For each protocol the program constructs ten 4x2 transition matrices. These matrices give the totals, over the ten successive blocks of ten trials, of the number of times each choice followed each of the four choice-reinforcement combinations. A separate matrix is calculated for each trial within the block of ten grouping.

By means of a control card these frequencies are accumulated for sets of N (maximum N = 100) protocols. From the summary matrices proportions are computed for the eight transitions. Choice repetition and alternation proportions and marginal choice proportions are also computed. (R. W. Frankmann)

1331-52076 T Civil Engineering. Stress Concentrating in Projecting Notches. The problem involves the determination of the elastic stress distribution in a bar with symmetrically disposed projecting notches subjected to axial loading. (The computer program is intended to solve the simultaneous equations arising from a finite difference approximation of the biharmonic equation). The main purpose of this analysis is to study the effect of certain geometrical parameters characterizing the notch profile on the stress distribution across particular sections of the bar, the ultimate aim of this investigation being the development of a correlation between the significant geometrical parameters (characterizing the notch profile) and the elastic stress concentration factors of projecting notches under axial loading. (Arnaldo T. Derecho)

1332-52077 Theoretical and Applied Mechanics. Fracture Toughness of Metals. The digital computer is to be used in the study of fracture toughness of metals in two ways. The first is the analysis of the data determined from laboratory work and the second is the determination of mathematical expressions to represent experimentally determined curves. This is done by numerical techniques such as the least square polynomial fit method. (W. Van Der Sluys)

1333-52078 Animal Science. Embryo Survival in Swine as Affected by High Temperature. This research investigates the effect of high ambient temperature on the embryo survival rate in swine. The analysis is by the method of least squares. (H. W. Norton)

1334-52080 Institute for Research on Exceptional Children. Gifted Research. This problem requires the examining various personality, intelligence, and academic achievement measurements obtained on several groups of gifted students; some analyses of variance will be made, correlations among certain areas of measurement, tests of significance, and factor analyses of selected elements of the information will be performed. (James J. Gallagher)

1335-52082 Chemistry and Chemical Engineering. Charge Transfer Complexes. There is considerable evidence to suggest that complexes of the charge transfer type may play a role in various reactions of biological importance. In line with a study of complexes of this type between several naturally occurring biochemicals, it is of interest to determine their molecular orbital energy levels. The usual LCAO approximations are used, and the computer is used in carrying out the matrix diagonalization involved in these calculations. Attempts will be made to make correlations between calculated energy differences in the systems, and the spectral, electrochemical, and biological properties of the complexes. (J. E. Wilson)

1336-52085 T Civil Engineering. Correlation of Terrain Quantification Factors. This research problem involves the correlation of terrain qualification factors with the associated soils. The computer is to be used to make an analysis of variance of a completely randonized design using an existing program. (Ray Vadnais)

1337-52069 T Chemistry and Chemical Engineering. Calculation of First Order Rate Constants. This program calculates the best fit least squares line through the points of a plot of lnY vs. time, the Y values being weighted by the factor $|Y-Y_{INF}|$. It also calculates the standard deviation in Y and determines the deviation of each Y value. It then compares this deviation in the individual Y's to some multiple of the standard deviation, which has been read into the program as the "criterion", and eliminates those Y-values whose deviation is greater than the multiple of the standard deviation. The elimination is accomplished by setting the weight of the eliminated point equal to zero. The infinity value is then changed in steps of 1% of the original infinity and the calculations are repeated. The infinity value which gives the smallest deviation in slope is the one which is finally used. (Eliz. McLeister)

1338-52087 T Chemistry and Chemical Engineering. Diene-Iron Carbonyl Complexes. This research problem is concerned with the determination of molecular bonding and geometric configuration in complexes of conjugated dienes with iron pentacarbonyl through a knowledge of chemical shifts and spin-spin coupling constants. Since the experimental spectra are quite complex, the IBM 7094 will be used in their analysis. An existing program will be used for this purpose.

The program consists of two parts. First, the energy levels are calculated from a set of trial parameters. This is done by diagonalization of the spin Hamiltonian matrix of the system, whose elements are easily calculable, by a series of two by two rotations until the off-diagonal elements are smaller than some prescribed value. Energy level differences are then correlated where possible with the experimental transition frequencies. Since many more transitions, or energy level differences, are possible than the energy levels themselves, the problem of determining the experimental energy levels is over-determined and can be solved by a least squares technique.

The next part of the program is an iterative scheme. Eigenvectors obtained from the diagonalization of the spin Hamiltonian matrix in the first part of the program are used to calculate improved values for the diagonal matrix of the Hamiltonian. These diagonal elements are used to calculate better

values of the parameters. These parameters are then used to calculate new energy levels, and the whole process is repeated; that is, the program iterates until the calculated energy levels converge on the experimentally determined values (usually five to ten iterations are adequate). Finally the spectrum is calculated with the values found for the magnetic parameters of the last iteration. The calculated and experimental spectra should then be nearly the same, and the parameters should be very nearly the correct ones. (Joseph C. Deck)

1339-52088 T Sociology. Suicide Study. This study will deal with the causes of some 2180 suicides occurring in Cook county, Illinois from 1959-1963. The computer will be used initially for frequency counts and the chi-square measure of association. Later other "standard library routines", which cannot be described in detail until the initial run is completed, will be used. (Maris)

1340-52089 Library Science. Evansville Reading Study. The purpose of the problem is to determine group characteristics of children who did not join a public library reading club: age, I.Q., etc. The computer is used to figure out means and standard deviations of the group. (John McCrossan)

1341-52090 Natural History Survey. Skunk Movements. This problem is to evaluate the effects of various environmental factors on the movements and distribution of striped skunks in northwestern Illinois, and to characterize the areas used by skunks with respect to habitat types and topographic conditions. (G. C. Sanderson)

1342-52091 T Chemistry and Chemical Engineering. Effect of Natural Convection in a Horizontal Tube. In the laminar region the secondary flow caused by bouyancy forces affects the heat transfer-coefficient. At low Reynolds numbers and high Grashof numbers, heat transfer-coefficients may be predicted using boundary-layer analysis if the core temperature distributions are known. The core temperature distributions are to be measured experimentally and used to solve the boundary-layer equations of continuity, momentum, and energy for free-convective flow inside a horizontal cylinder. Both approximate solutions

based on the integral method, and exact solutions using series expansions are to be considered. Either method reduces the problem to the solution of several ordinary differential equations which will be solved numerically on the computer. (D. P. Siegwarth)

1343-53007 Vocational and Technical Education. Employment-Education Attitudes. Attitudes on about 35 variables were measured for 3 different groups. Correlations and frequency of responses are calculated and compared between groups. SSUPAC programs will be used. (Whitmarsh)

1344-53008 T Civil Engineering. Numerical Solution of Shells. The research problem consists of numerical solution of shells by using a model analogue. The computer is used for generating the equilibrium equations of the model. These equations are a set of linear algebraic simultaneous equations which are solved by some numerical technique. (Bijan Mohraz)

1345-53009 T Civil Engineering. Numerical Solution of Discrete Models. The solution of the shell type structure is achieved by finding an analogous lattice type structure to replace the continous shell surface. The force resultants in the lattice structure are then found by making use of STRESS (Structural Engineering System Solver). (E. Benard)

1346-53010 State Water Survey. Coalescence Delay. When two objects approach each other in a viscous medium, the medium must be forced out from between the approach surfaces in order for a collision to take place. The computer is to be used to solve the non-linear differential equations of motion which describe the motion of various approaching surfaces. (R. G. Semonin)

1347-53011 Mechanical Engineering. Thermal Stress in Nozzle. The problem aims to define the temperature distribution in the diverging section of a De Laval nozzle. Having this, it is then desired to analyze the thermal stresses and resulting configuration due to thermal expansion. (Ronald Harris)

1348-53013 T Dairy Science. Analysis of Diallel Crosses. It is the intention of the prime user to develop and test programs for the analysis of data collected from experiments involving Diallel crosses of a number of genetically different strains of mice. The calculations will be concerned mainly with the analysis of variance, and covariance. These procedures are to be part of a thesis project. (A. C. Singer)

1349-53014 Mechanical Engineering. Aerodynamic Nozzles. The computation of Aerodynamic nozzles for wind tunnel uses will be carried out using the method of characteristics. In such cases the use of small mesh sizes is desirable to obtain accurate results at high mesh numbers and consequentally requires large numbers of calculations. Boundary layer connections will also be made for each location along the nozzle wall by a step by step method so that the flow obtained is parallel and uniform. (Robert A. White)

1350-53018 T Aeronautical and Astronautical Engineering. Dynamic Viscoelasticity. The nature of the research problem is a theoretical description of cylindrical stress waves, first, in an elastic hollow cylinder, second, in a viscoelastic hollow cylinder.

The computer will be used to solve transcendental equations involving Bessel functions. Once the zeroes of these transcendental equations are determined, residues will be found which will determine the form of the final answer. (J. W. Schmidt)

1351-53019 Physical Education for Women. Effects of Course in Basic Movement Upon Learning in Subsequent Activity Courses. The problem is to determine what effect the skills and principles learned in Basic Movement have had on the rate and extent of learning in other physical education activity courses in the Basic Instruction Program.

The students in eight activity courses for each of two semesters were divided into two groups: those who had previously taken Basic Movement composed the experimental group and those who had not made up the control group.

An initial and final skill test was given to all subjects, as well as an initial and final attitude test, a final written exam, and a subjective skill rating by each teacher.

The mean and standard deviation for each group for each test and for the differences between initial and final tests are to be computed. Using the sampling theory, the "t" is to be computed to determine the significance of the differences between the scores of the experimental and control groups.

The subjects' scores are to be further analyzed according to the amount of previous experience in the activity to determine whether Basic Movement helps beginners more than highly skilled players. (Charlotte Lambert)

1352-53020 Psychology. Child Behavior Ratings. A set of 63 behavior rating scales has been used to assess a sample of 163 eleven- and twelve-year-old children. The following analyses will be compared: a) orthodox factor analysis, using 10 factors and rotation by Varisim and Rotoplot; b) factor analysis of all real factors obtained when squared multiple correlations are used in the main diagonal of the correlation matrix, rotation by Varisim and Rotoplot; c) factor analysis of the correlations corrected for bias (i.e., correction for "shrinkage"), rotation of all real factors by Varisim and Rotoplot. (J.M. Digman)

1353-53021 Division of University Extension. Correspondence Study. A study of students enrolled in correspondence courses, offered by the University of Illinois, which attempts to identify differences between those who do and who do not complete the courses with respect to students' prior education background, university status, and other characteristics. (M.T. Smith)

1354-53022 Division of University Extension. Management Education And Training. This study is an attempt to determine attitudes, opinions, areas of interest and need, and receptiveness on the part of a selected sample of business firms with respect to management development and management education programs. (M.T. Smith)

1355-53023 Psychology. Content Scales. This research concerns the reliability, validity and nonactive characteristics of a group of content scales developed by the user as an alternative method of interpreting the Minnesota Multiphasic Personality Inventory. Previously developed FØRTRAN programs will be employed for scale scoring and the assessment of such characteristics as reliability, item endorsement percentages and scale intercorrelations. SSUPAC programs will be employed for Missing Data Correlations, Principal Component Analysis and Varimax Factor Rotation. Subject populations on whom these analyses will be performed include: college students from Stanford University, University of Oregon, University of Minnesota and the University of Illinois; military personnel from Chanute Air Force Base; psychiatric patients from Kankakee State Hospital and the Psychiatric Clinic at Chanute Air Force Base. (Jerry S. Wiggins)

1356-53024 T Psychology. Objective Personality Factors. Six objective personality factors were measured on 130 subjects with 43 variables. These subjects are comprised of schizophrenics, T.B. patients, military normals and military rejects. Differences between groups are expected. Then a factor analysis will be carried out to check the structure of the factors to see the degree of match between different methods of estimating factors. (Larry Killian)

1357-53012 Agronomy. Soil Conservation Needs Inventory. This problem is concerned with the assembling and organization of presently available sample soil survey data now on soil maps, tabulation sheets and magnetic tape to permit the evaluation of soil type, slope and erosion conditions of soil association areas and counties in Illinois. Fortran programs will be written to perform the summarizations of the data. (Carmer)

1358-53025 T Agronomy. Soybean Genetics. This problem is concerned with obtaining the analysis of variance on data involving 9 genotypes of each of 2 soybean varieties planted at 2 different dates during 1964. Suitable programs for this purpose are available. (Wan)

1359-53026 T Psychology. Moderated Prediction Program. The number of dimensions needed to furnish individual weights for multiple predictors and criteria will be determined. The data are evaluations of and beliefs about candidates and issues in the 1964 election. The major tool will be a recently developed routine which accents predictors and criteria and computes weights for individuals, predictors, and criteria. These weights are computed on the basis of hypothetical scores on (unspecified) moderator variables. A further aspect of the analysis will be to develop estimates of the moderators on the basis of demographic and test data on the subjects. (Arthur R. Carlson)

1360-53027 T Chemistry and Chemical Engineering. Kelvin-Helmholtz Instability. Given an equation describing the Kelvin-Helmholtz neutral stability condition of a liquid film flowing horizontally below a turbulent gas stream, it is desired to find the minimum gas velocity u_1 required to effect this instability, as a function of wave number k_x. It is also desirable to find the relationship of u_1 and k_x near the above mentioned minimum. Since u_1 is an implicit function of k_x with both variables represented in the logarithm and hyperbolic tangent functions, and since this neutral stability condition is a function of several parameters, the computer could be used to calculate the solutions rapidly and accurately. (D. E. Woodmansee)

1361-53028 Electrical Engineering. Sohtrop 566. The computer will be used for familiarization with the various languages of Porthos and for proficiency in programming as applied to business type problems (rather than scientific problems). (D. A. Bishop)

1362-53032 T Vocational and Technical Education. School Citizens Committees. Comparisons will be made relative to the information possessed and opinions held concerning local public schools by a random sample of telephone subscribers in three pairs of communities. Communities comprising each pair will be similar except for the existence of a committee of lay citizens which acts in an advisory capacity to the local board of education.

Several correlations will also be computed between information and opinions of the respondents and certain biographical characteristics of the respondents. (John Terwilliger)

1363-53033 T Aeronautical and Astronautical Engineering. Stress Waves in a Viscoelastic Sphere. The problem involves solving the stress wave equation for a viscoelastic sphere. To gain a knowledge of the topic an elastic sphere will also be treated. This will yield not only a feel for the topic but will also provide a standard for comparison.

In the initial elastic case a half interval Fourier transform is used. The machine is used to aid in inverting the transform by finding the roots of the denominator. The equation is then integrated by the method of residues.

It is also expected that numerical integration will be used in the solution of the problem. (John S. Kirby)

1364-53035 T Electrical Engineering. Hysteresis in Non-Linear OSC. The investigation is concerned with the influence of marked hysteresis on a grossly nonlinear, current stable, negative resistance oscillator. The negative resistance device is represented by a power series. The indicator must be represented by two related power series with switching information to determine the time intervals during which each applies. The equations which must be solved are of the form:

$$[a_1 + 3a_3 x^2 + 5a_5 x^4 + \ldots] \frac{dx}{dt} + [\pm 2c_2 + 6c_3 x \pm 12c_4 x^2 + \ldots] \left(\frac{dx}{dt}\right)^2$$

$$+ [c_1 \pm 2c_2 x + 3c_3 x^2 \pm 4c_4 x^3 + \ldots] \left(\frac{d^2x}{dt^2}\right) + \frac{1}{c} x = 0$$

The sign on the terms indicated as $\pm$ must be selected by switching information.

The solution of this equation will utilize a computer subroutine known as MIDAS (Modified Integration Digital Analog Simulator) as modified by Professor McVay to operate under PORTHOS on the University of Illinois IBM 7094. (Arnold W. Dipert)

1365-53036 T Electrical Engineering. Radiation From Periodic Structures. The computer is to be used to obtain numerical results for certain boundary value problems of electromagnetic field theory. Evaluation of certain functions expressed as infinite products, finding the Fourier coefficients of these functions, and obtaining the roots of transcendental equations involving these functions will be required. (D. S. Karjala)

1366-53039 Library Science. State Library Consultants: A survey. Information is urgently needed which will be helpful in recruiting and training additional state library consultants, especially since passage of the Library Services and Construction Act has lent financial impetus to statewide library programs; yet the library profession in general knows little about what consultants do and how they should be prepared for their jobs.

The present study, "State Library Consultants: A Survey of Their Backgrounds, Duties, and Training Needs," uses an eight-page printed questionnaire to solicit information about the career choices, educational backgrounds, job experiences, duties, job satisfactions, and training needs of the present consultants In addition to describing these aspects of consultants and their jobs, the study will explore certain possible relationships between variables (e.g., differences in the satisfactions expressed by various age groups) in order to formulate hypotheses for further study.

The analyses to be performed by computer will be largely frequency counting. Possible relationships will be determined by means of chi square analyses. Tests for statistical significance of percentage differences may also be run. (Marie Long)

1367-53040 Economy. Bank Model-2. The nature of the problem is to develop an econometric model to explain bank behavior in determining levels and/or changes in level of borrowed reserves, excess reserves, Federal funds supplied, and loan behavior for commercial and industrial loans, consumer loans, agricultural loans, and mortgage loans. The particular programs to be used on the model are from SSUPAC. They consist of unistack, array manipulations, matrix algebra operations and K class estimation. (D. Hodgman)

1368-53041 T Psychology. Factor Analysis of Ordinal Data. The goal of this project is to find an algorithm that can, in a reasonable amount of time, generate a factor analytic solution to a set of data under the restriction that the reproduced data show the same rank-orders as the input data. Both steepest descent and direct search methods will be used to do rotations in a multidimensional Euclidean space and to find optimal combinations of the rotated vectors. (R. F. Koopman)

1369-53042 Institute of Government and Public Affairs. Illinois House Election, 1964. The subject of this research project is the election at-large of all 177 members of the Illinois House of Representatives in 1964.

The problem is to analyze the vote by state, county, and other geographic units in terms of the vote for other offices, various candidate characteristics, and straight and split ticket voting. Simple and Multiple correlations and printing in rank order will be used. (James H. Andrews)

1370-53043 Agricultural Economics. Markov Chain Analysis. Data on size of farm enterprises for 5 areas in Illinois for the period 1946-1963 will be analyzed. Frequency counts will be made on the year-to-year movement of enterprises from size class to size class. This will be done with the cross-tabulation program in SSUPAC. From these, transition probability matrices will be calculated. These matrices will be tested with the X^2 test to determine whether a first-order Markov process is present. Finally, equilibrium vectors will be derived. These show the steady state distribution of farms by size of enterprise classes. (E. R. Swanson)

1371-53044 T Nuclear Engineering. Repetitive Pulsing. This research problem involves the study of the power and temperature histories of the Illinois TRIGA Reactor while pulsing at short time intervals. Theoretical models will be developed that represent these histories and that are in the form of differential-integral equations.

The computer will be used to solve these equations and compare the results to experimental data. A percent error between the model calculations and the experimental values will then be found. (H. A. Kurstedt)

1372-53046 Institute of Communications Research. Simulation of Clinical Judgment. Utilizing judgments of psychosis-neurosis made by clinicians from profile data, an attempt is being made to simulate such judgments. Previous work has shown that a computer can handle input information more efficiently and accurately than clinicians. If it can be determined what, exactly, clinicians are doing when they make clinical judgments it would be possible to retrain

them in order that they can approach the accuracy of computers. The purpose of this study, then, is to determine how clinicians are utilizing the input data in arriving at their judgments with particular attention to the question of whether clinicians are operating in a linear fashion or, as they claim, in a configural fashion. The dimensions of such judgments will also be located. The primary methods of analysis will involve matrix manipulations, e.g., inversion, multiplication, transposition, factor analysis, and standard inferential statistics. (Nancy Wiggins)

1373-53047 Institute of Communications Research. Political Machines. The purpose of the study is to measure the strength of the Democratic Party in New York City from 1930 through 1957. The major hypothesis is that the Democratic Party has lost strength in areas of low socio-economic status and has gained strength in higher socio-economic status areas. In addition, minority party strength is being measured.

Data have been collected from a random sample of electoral districts in New York City for each year from 1930 through 1957. The electoral districts have been matched with census tract information.

The analysis is straightforward, using correlation techniques, descriptive statistics, etc. (Rita Simon)

1374-53048 T Economics. Aggregate Consumption Functions. Two-stage least-squares regression will be used to estimate the parameters of various aggregate consumption functions. Annual and quarterly data (for the United States) will be used for the variables. (George D. Craig)

1375-53050 Department of Computer Science. Conditional Wiener Integral. The conditional Wiener integral arises in numerous physical problems which are described in terms of a parabolic differential equation. The conditional Wiener integral may be approximated by a multidimensional integral of some high order. The computer will be used to evaluate such multidimensional integrals in order to test the accuracy of the approximation applied to Wiener integrals involved in several physical problems of interest in statistical mechanics. (H. F. Jordan)

1376-53051 T Department of Computer Science. Threshold Logic. The purpose of this investigation is to extend the study of threshold logic. The investigation will center about a computer program to find the threshold functions of eight variables. To improve computation techniques, new properties of threshold functions will be explored. The enumeration of the functions will serve to verify conjectures which have been made about threshold functions and may reveal new ones.

The mathematical method to be used is as follows:

1. From the Boolean functions of eight variables, candidates will be selected which will probably be threshold functions.
2. The linear programming problems formulated for these candidates will be solved.

Efficiency of computation depends on the method of selection of candidates, minimization of the number of candidates which will turn out to be threshold functions, and the computation time of the linear program. If the former is minimized, the number of linear programming problems which will have to be solved is minimized. The matrix of each linear programming problem will be of the order of 9 by 10 to 20; thus the computation time of each linear programming problem should not be long. (John A. Rohr)

1377-53052 Psychology. Plasmode. This research problem involves the construction of a model factor analytic problem which may be used to examine various aspects of factor analytic methodology. The problem begins with 1st, 2nd, and 3rd order factor matrices for errorless variables given. The computer must be used to determine values of variables which will produce these matrices, and then add errors to the values obtained. The raw data obtained from this will then be factor analyzed and compared with the original factor matrices given at the beginning of the study. Computer programs to be used are: correlations, iterative factor analysis, maxplane, and transformations. (Max Bowen)

1378-53053 Nuclear Engineering. Problem 01. This problem involves the solution of reactor kinetics equations by various mathematical approximations. These equations are usually transcendental in nature. (Sheldon Levin)

1379-53054 T Physics. Optical Absorption in AGCl. The object of this research is to measure the optical absorption coefficient of AGCL. The computer will be used to calculate theoretical values of the optical absorption coefficient and to compare them to the experimental values.

The computer will also be used to calculate theoretical phonon energies from the absorption coefficient. (Lew Joesten)

1380-53055 Agricultural Economics. Price Analysis. The research problem is an experiment in short term grain price forecasting, the results of which will be used in extension programs. Primarily multiple regression equations are contemplated. (Hieronymus)

1381-53058 Bureau of Economic and Business Research. County Income Estimation. United States Department of Commerce total wage and salary figures will be allocated to the 102 Illinois counties. From our own programs the computer will perform routine divisions, multiplications, and will make comparisons which will, if necessary, adjust results to be consistent with predetermined norms. At some later date, regression estimates will be made. (N. M. Ford)

1382-53059 Animal Science. Statistical Genetics of Sheep. Data on lambing rate, growth rate of lambs, and carcass characteristics of lambs, etc. will be analyzed to establish their heritabilities and genetic correlations. Generally analysis is by the method of least squares. (H. W. Norton)

1383-53062 Civil Engineering. Inelastic Spherical Wave Propagation. Boundary conditions in a problem of stress wave propagation in spherically symmetric solids with elastic and elastic-perfectly plastic stress-strain relationships are investigated. For the simulation of spherically symmetric solid continua, a lumped-parameter model is utilized. In the spherical polar coordinate system the model is mathematically consistent with a central finite difference formulation of the corresponding theory of solid continua, and consequently, the solution corresponds to a central finite difference solution to the problem.

The resulting set of equations of motion are integrated by means of a numerical integration procedure.

The approach proposed for the determination of strains and stresses at a boundary point consists in the expansion of the expression for the strains by means of Taylor series about a neighboring node point.

An existing program will be used and modifications introduced wherever necessary. (Jorge Ishizawa)

1384-53063 Theoretical and Applied Mechanics. Deformed Wire Data Reduction. A least squares library routine will be used to analyze a relatively large amount of data.

The research problem is an experimental examination of a wide range of patterns of deformed wire reinforcement. (Harry Kohler)

1385-53064 Botany. Mount Washington Alpine Study. This problem is concerned with determining the degree of correlation between seven environmental factors and dry matter production of natural plant communities at high altitudes (6000 feet above sea level). Programs for simple correlation and multiple regression will be utilized. (Bliss)

1386-53066 Agronomy. Bioma Thematical Relationships. In order to explain biological responses to various stimuli it is often useful to formulate a mathematical model to describe the responses. The computer will be utilized for the computations needed to estimate parameters of the models and to test the adequacy of the models. (Carmer)

1387-53067 Nuclear Engineering. Gamma-Electric Cell. The gamma-electric cell is a device that converts the energy of gamma rays, which are a by-product of nuclear reactions, directly to electrical energy by means of computer electrons. The computer will be used to conduct a parameter study of a theoretical model of the gamma-electric cell. A number of numerical integrations are required for which standard subroutines will be used. (Henry Sampson)

1388-53068 State Water Survey. Flight-Leg-Cross Section Analysis. The program is kept as simple as possible and the computations are restricted to simple algebra and trigonometry. The input consists of observation number, time, latitude, longitude, height, direction and velocity of the wind and temperature as reported by the pilot in the form of a RECCO code and can be punched on cards from the observation sheet without any modification. The printout consists of observation time, latitude and longitude of observation points as well as that of the trajectory endpoints, wind direction in degrees, wind velocity in metres per second, height in metres, temperature in ^{o}C, pressure in mb, potential temperature in ^{o}K and wind components in m. sec^{-1} normal and parellel to the cross-section centered on time TC.

The program is only applicable to unidirectional flights along straight flight legs. Flights along a curved or bent flight path have to be broken up into such legs which have to be processed separately. This applied also to flights in both directions along the same leg. (Robert Sinclair)

1389-53069 T Psychology. Multivariate Assessment of Personality Change. The problem being dealt with in this study is that of separating personality dimensions of change from those dimensions of personality which are relatively stable. The principal analytic method being used is factor analysis. The more recent developments and innovations in factor analysis assume the use of high speed digital computers. Involved in such an analysis are procedures involving calculations of eigenvalues and eigenvectors, and matrix multiplication and inversion. (J. Nesselroade)

1390-53070 Psychology. Multiple Frequency Distributions. A straightforward use of SSUPAC's TRANSFORMATION and FREQUENCY programs to obtain two-way frequency distribution tables (counts and percentages) from 8 variables is contemplated. Data obtained from verbal learning experiments will be used. (Webber)

1391-53071 T Chemistry and Chemical Engineering. Boundary Layer with Reaction. The concentration profile, within a boundary layer in which a chemical reaction is occuring, can be determined analytically for some very simple flow systems. However for more complicated geometries such as flow past a sphere or a cylinder, a closed form expression for the concentration profile has not been obtained yet.

The present work deals with the determination of the concentration profile of systems of various complexities, either by a computer evaluation of a closed form expression or by a direct solution of a partial differential equation by the method of finite differences. (Harry Dimopoulos)

1392-53073 Zoology. Osteometric Variation of Tadarida brasiliensis Bones. The particular problem consists of an osteometric analysis of the bat Tadarida brasiliensis. In particular the bones of the forelimb (wing), the cranium, and baculum (penis bone) are being measured. The data will be analyzed by various statistical applications. This data will be related to specific functional evolutionary adaptations and the aerodynamics of bat flight. (Charles A. Long)

1393-53074 Speech and Theatre. Speech Pedagogy Study. The primary purpose of the present study consists of an effort to discover more efficient means of instructing a multi-section course which attempts to serve approximately 1200 students a semester. Recent studies of pedagogical techniques have indicated that some non-directive, student centered teaching methods are more efficient and effective than the more traditional didactic methods. The conclusions to such studies have often been severly limited, however, because of inadequate and/or incomplete modes of statistical analysis. The objective of the present study is to identify and put into the analysis the many variables which have been argued as relevant to the outcomes of various teaching methods.

For a large number of variables, any method of regression analysis requires a large number of calculations. Most methods of regression analysis are based on techniques particularly adaptable to a desk calculator where a minimum transcription of intermediate answers is desirable. In the "Stepwise Multiple Correlation" program of the Statistical Service Unit Library, intermediate results are used to give valuable statistical information at each

step in the calculation. By using the computer it will be possible to use the intermediate answers to control the method of calculation -- an impractical procedure in hand calculating procedures. The most important property of this particular program is that only significant variables are included in the final regression equation, thus reducing significantly the amount of time normally spent in interpreting results. (Robert Ince)

1394-53075 Civil Engineering. Dynamic Response of Multistory Buildings. The purpose of this study is to determine the response of two buildings, Olin Hall, USC, and Central Engineering Hall, JPL, to earthquakes such as El Centro. Olin Hall is a modern five-story reinforced concrete building while Central Engineering Hall is a nine-story steel frame. Both are located in Southern California. (J. W. Melin)

1395-53076 T Economics. Interest Rates. The research problem involves determining the effect of interest rates on investment spending. The computer will be used to do multiple correlations in this investigation. The computer has already been programmed to do this. (Spencer Hodges)

1396-53077 Civil Engineering. Hydrograph Routing in Natural Channels. Using the method of characteristics, a set of finite difference equations can be found for the differential equations of unsteady, non-uniform flow in open channels. By making an initial assumption of the depths at various points in the channel and applying the finite difference equations with appropriate boundary conditions, successive approximations of the depths will converge to the steady flow depths in the channel. By modifying the parameters that govern the flow such as the channel roughness and slope, a mathematical model can be developed for the reach of stream under consideration. This modification can be continued until the depths calculated by the program compare favorably with the observed depths in the river reach. Subsequent to the development of a mathematical model, unsteadiness in the form of a flood hydrograph will be imposed on the stream and routed through the reach by the use of the same finite difference equations. (John Weggel)

1397-53078 Civil Engineering. Monte Carlo Gamma Penetration. The Monte Carlo process for calculation of gamma ray penetration process through media is quite standard. It involves use of a random number generator subroutine to find location of each interaction point in a photon history, followed by similar statistical means of making decision as to whether photon is absorbed or scattered. Directions and subsequent photon energy values are also obtained through routines involving random numbers. This is carried until photon disappears or passes out of the medium. There is a number of techniques for improving the process so as to get a highly accurate answer with a minimum number of histories and a minimum amount of computer time. This particular problem involves a possibly new technique which has never been fully appreciated before. This involves a transformation of the photon flux variable by multiplication by an exponential factor. It results in a slightly more complex type of history, but an overall saving in computer time. This present work is an attempt to prove the validity of the technique prior to a more detailed effort under outside sponsorship. (A. B. Chilton)

5.3 Instructional Problem Specifications

During the first quarter of 1965, six instructional problem specifications were submitted to the IBM 7094 for computation. The following brief descriptions of these problems have been prepared for inclusion in this report by those submitting them.

I162-51043 Nuclear Engineering 455. Problem Number 1. It is very desirable that graduate students in nuclear engineering become acquainted with current digital computer programs available for the solution of neutron transport problems. It is planned to assign in this course problems on reactor criticelity, resonance escape, neutron spectra and neutron diffusion which could be solved by using and/or adapting existing codes. Examples are the Los Alamos SNG-code, the Atomic International AIM and FAIM codes, and the similar programs. Students in Phys/NE455 could be grouped into sections of 3-4 students and each such section would do one or at most two computer problems. (F. T. Adler)

I163-51052 Agricultural Economics 230. Business Management Simulation. The business management simulation is a classroom exercise in business management. The computer program consists of equations representative of the marketing functions of procurement, processing, distribution and selling. Schedules of demand and price relationships as well as coefficients for the effects of advertising are an integral part of the simulation.

The program was designed as a tool to teach management principles to students in the Department of Agricultural Economics. The computer is used to make the calculations and to print out financial statements. (R.P. Bentz)

I164-51060 Aeronautical and Astronautical Engineering 216. Compressible Gas Dynamics Course. The machine will be used to solve relatively complex compressible flow problems to generate information for the students. The students will be asked to duplicate a few points in the calculation and to compare the results to approximate theories discussed in class. (Roger Strehlow)

I165-51062 Mining, Metallurgy, and Petroleum Engineering 497. Slip Angle Statistics. A statistical analysis of the type of faulting associated with earthquakes, from the slip angle or calculated from earthquake fault plane solutions is attempted. Computer required due to the large amount of information material. Only standard library routines will be involved. (Hans Pulpan)

I166-52005 Mechanical Engineering 341. Problem Number 1. Machine Design. Shaft deflection, normally an approximation or graphical calculation, is an excellent problem to illustrate to the students the capacity of the computer to obtain a solution requiring repeated long and complex calculations. (Seyfarth)

I167-53057 Mechanical Engineering 423. Pull-Down of Temperature. It shall be the objective of this problem and solution to calculate the rate at which the temperature in a refrigerated space can be reduced. Knowing the capacity of the refrigeration unit and the thermal characteristics of the structure, the computer will be used to perform a step-wise calculation in the following manner. At the initial temperature of inlet air to the evaporator, the refrigeration capacity of the unit will be determined. This capacity will be available to overcome heat gain from the ambient as well as to reduce the temperature of the space. The thermal capacity of the structure multiplied by the arbitrarily-assumed temperature increment and divided by the available pull-down capacity will determine the time required for reducing the temperature. The computer will then move to the calculation of the next temperature increment, and the cumulative time will be the total time required for temperature pulldown. (Stoecker)

TABLE I - IBM 1401-I

Summary of Use

January, 1965

Scheduled Engineering	2:45
Unscheduled Engineering	12:40
Machine Maintenance	6:51
7094 Preparation	421:29
Listing	20:07
Monthly Report Listing	:40
Code Checking	17:52
Tape Duplication	:26
Tape Dumping	1:17
Reproduction	26:34
Scanning Measuring Projector	16:20
Tape Testing	:20
Tape Labeling	:40
Illiac II Preparation	:39
Idle	48:57
Total	577:37

TABLE II - IBM 1401-I

Summary of Machine Errors

January, 1965

1401 Main Frame	1
1402 Card Reader-Punch	2
1403 Printer	3
729 V Tape Drive	6
Total	12

TABLE I - IBM 1401-II

Summary of Use

January, 1965

Scheduled Engineering	8:55
Unscheduled Engineering	6:02
Machine Maintenance	6:24
7094 Preparation	390:46
Listing	14:00
Monthly Report Listing	4:33
Code Checking	29:39
Tape Duplication	1:40
Tape Dumping	4:18
Reproduction	22:11
Scanning Measuring Projector	17:08
Tape Testing	1:00
Tape Labeling	3:14
Illiac II Preparation	3:59
Idle	50:36
Total	564:25

TABLE II - IBM 1401-II

Summary of Machine Errors

January, 1965

1401 Main Frame	1
1402 Card Reader-Punch	6
1403 Printer	2
729 V Tape Drive	2
Total	11

TABLE I - IBM 7094

Summary of Use

January, 1965

Scheduled Engineering				34:30
Unscheduled Engineering				8:57
Maintenance				6:02
Idle				13:18
Miscellaneous (Operator training, tape rewind, Tape mounting, both system and user, Rerun of failing problems, Destruction of clock reading)				83:00
Total Use				
Training and Education			58:16	
University Administrative Overhead Use			19:50	
System Updating			4:24	
System Modification and Improvement			27:42	
System Modification and Improvement (rel)			27:59	
Customer Use				
In system		186:54		
Relinquish				
AGEC	5:44			
CHE	:27			
NUCE	:05			
PHYCS	84:29			
		90:45		
Special Short Shots		1:03		
		Customer Use	278:42	
		Total Use		416:53
		Total Time On		562:40

TABLE II - IBM 7094

Summary of Machine Errors

January, 1965

7094	2
1301 Disk Storage Unit	2
729 VI Tape Drive	7
721 Card punch	1
716 On-Line Printer	1
Total	13

7094 Table III. January 1965

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	TandE[2]	Res	Total	TandE[2]	Res	Total	TandE[2]	Res	Total
AAE	105	124	229	1	5	6	2 37.0	3 30.4	6 7.4
ACCY	0	43	43	0	1	1	0.0	1 56.8	1 56.8
ADV	0	1	1	0	1	1	0.0	2.2	2.2
AGE	0	49	49	0	3	3	0.0	36.2	36.2
AGEC	7	120	127	1	15	16	1.6	7 7.0	7 8.7
AGED	0	1	1	0	1	1	0.0	0.4	0.4
AGR	0	4	4	0	1	1	0.0	26.3	26.3
AGREX	0	14	14	0	1	1	0.0	7.6	7.6
AGRON	512	161	673	1	15	16	12 6.9	5 29.3	17 36.3
ANGEN	0	3	3	0	1	1	0.0	0.7	0.7
ANS	0	59	59	0	3	3	0.0	1 2.8	1 2.8
ANTH	0	21	21	0	1	1	0.0	28.3	28.3
BEDRE	0	8	8	0	1	1	0.0	1 13.1	1 13.1
BOT	0	29	29	0	1	1	0.0	18.5	18.5
CE	747	984	1731	4	29	33	10 57.5	30 1.7	40 59.3
CERE	6	0	6	1	0	1	4.2	0.0	4.2
CHE	11	998	1009	1	42	43	5.7	32 25.9	32 31.7
COMM	0	5	5	0	1	1	0.0	12.9	12.9
CRC	0	11	11	0	1	1	0.0	32.0	32.0
CSL	0	3	3	0	1	1	0.0	0.5	0.5
DCS	58	146	204	2	7	9	59.5	2 47.2	3 46.7
DNSTU	0	28	28	0	1	1	0.0	14.5	14.5
DS	0	52	52	0	3	3	0.0	46.7	46.7
ECON	224	20	244	2	3	5	2 24.3	16.3	2 40.7
ED	0	69	69	0	3	3	0.0	1 8.1	1 8.1
EDTES	0	11	11	0	1	1	0.0	8.9	8.9
EE	314	412	726	9	16	25	3 39.8	9 20.3	13 0.2
FIN	0	11	11	0	1	1	0.0	10.7	10.7
GENE	135	0	135	2	0	2	1 48.2	0.0	1 48.2
GEOG	0	8	8	0	1	1	0.0	9.7	9.7
GEOL	0	40	40	0	2	2	0.0	19.8	19.8
GSBA	157	0	157	1	0	1	3 9.1	0.0	3 9.1
HORT	0	10	10	0	2	2	0.0	32.8	32.8
ICR	0	68	68	0	1	1	0.0	1 28.3	1 28.3
IE	124	0	124	3	0	3	42.5	0.0	42.5
IED	0	4	4	0	1	1	0.0	1.6	1.6
IGPA	0	30	30	0	1	1	0.0	1 22.7	1 22.7
INADM	106	0	106	1	0	1	32.5	0.0	32.5
IREC	0	9	9	0	2	2	0.0	22.6	22.6
LIBS	0	2	2	0	1	1	0.0	4.8	4.8
MATH	1437	0	1437	3	0	3	13 23.8	0.0	13 23.8

7094 Table III. January 1969 continued

Dept[1]	Number or Runs			Number of Specs			7094 Usage in Hours-Minutes		
	TandE[2]	Res	Total	TandE[2]	Res	Total	TandE[2]	Res	Total
ME	315	318	633	5	18	23	3 13.1	9 5.9	12 19.0
MKTG	0	5	5	0	2	2	0.0	24.9	24.9
MMPE	32	119	151	0	6	7	28.6	2 16.4	2 45.1
MUSIC	0	6	6	0	1	1	0.0	6.2	6.2
NUCE	17	179	196	3	8	11	41.8	4 43.1	5 25.0
OIR	0	176	176	0	3	3	0.0	3 57.4	3 57.4
PEM	0	14	14	0	2	2	0.0	36.5	36.5
PHYCS	0	1605	1605	0	31	31	0.0	136 6.3	136 6.3
PROVS	0	6	6	0	1	1	0.0	17.9	17.9
PSYCH	0	361	361	0	18	18	0.0	8 42.3	8 42.3
SCS	0	8	8	0	1	1	0.0	12.4	12.4
SGS	0	21	21	0	1	1	0.0	9.7	9.7
SOC	0	16	16	0	1	1	0.0	10.1	10.1
SOCW	0	2	2	0	1	1	0.0	16.3	16.3
SWS	0	109	109	0	11	11	0.0	3 26.3	3 26.3
TAM	103	122	225	3	7	10	1 18.8	1 37.0	2 55.9
WPGU	0	8	8	0	1	1	0.0	5.5	5.5
XSSS[3]	0	169	169	0	1	1	0.0	1 2.5	1 2.5
ZOOL	0	21	21	0	1	1	0.0	33.8	33.8
Subtotal	4410	6823	11233	44	285	329	58 15.8	278 41.9	336 57.8
DCSYS[4]	0	1061	1061	0	21	21	0.0	55 40.7	55 40.7
XDCS[5]	0	56	56	0	1	1	0.0	4 24.1	4 24.1
SSUAD[6]	0	529	529	0	2	2	0.0	19 50.2	19 50.2
Total	4410	8469	12879	44	309	353	58 15.8	358 36.9	416 52.8

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Improvement and Modifications
5 System Updating
6 University Administrative Overhead Use

TABLE I - IBM 1401-I

Summary of Use

February, 1965

Scheduled Engineering		6:20
Unscheduled Engineering		7:30
Maintenance		10:48
7094 Preparation		398:34
Listing		18:05
Monthly Report Listing		1:25
Code Checking		16:56
Tape Duplication		:15
Tape Dumping		5:56
Reproduction		33:11
Scanning Measuring Projector		13:43
Tape Testing		1:33
Idle		50:50
	Total	565:06

Table II - IBM 1401-I

Summary of Machine Errors

February, 1965

1402 Card Reader Punch		3
1403 Printer		5
729 V Tape Drives		2
	Total	10

Table I - IBM 1401-II

Summary of Use

February, 1965

Scheduled Engineering	7:30
Unscheduled Engineering	8:54
Maintenance	10:51
7094 Preparation	388:12
Listing	16:57
Monthly Report Listing	2:52
Code Checking	40:24
Tape Duplication	4:35
Tape Dumping	3:54
Reproductions	29:31
Scanning Measuring Projector	8:04
Tape Testing	2:50
Tape Labeling	:20
Idle	45:15
Total	570:09

Table II - IBM 1401-II

Summary of Machine Errors

February, 1965

1401 Main Frame	2
1402 Card Reader Punch	3
1403 Printer	5
729 V Tape Drives	2
Total	12

Table I - IBM 7094

Summary of Use

February, 1965

Scheduled Engineering				42:24
Unscheduled Engineering				:40
Maintenance				8:09
Idle				38:45
Miscellaneous (operator training, tape rewind, tape mounting, both system and user, rerun of failing problems, tape skipping, destruction of clock reading)				66:13
Total Use				
Training and Education			12:57	
University Administrative Overhead Use			16:21	
System Updating			7:15	
System Modification and Improvement			26:12	
System Modification and Improvement (Rel)			14:03	
Customer Use				
In System		223:42		
Relinquish				
AGEC	8:25			
CSL	1:04			
MMPE	:09			
PHYCS	81:27			
		91:05		
Special Short Shots		2:15		
	Customer Use		317:02	
	Total Use			393:50
	Total Time On			550:01

Table II - IBM 7094

Summary of Machine Errors

February, 1965

Porthos System Errors	5
7094	1
729 VI Tape Drives	14
Total	20

7094 Table III. February 1965

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	TandE[2]	Res	Total	TandE[2]	Res	Total	TandE[2]	Res	Total
AAE	25	163	188	3	6	9	11.3	4 42.1	4 53.5
ACCY	0	3	3	0	1	1	0.0	1.7	1.7
ADV	0	1	1	0	1	1	0.0	4.0	4.0
AGE	0	69	69	0	3	3	0.0	1 0.4	1 0.4
AGEC	3	147	150	1	14	15	1.9	12 29.2	12 31.1
AGED	0	2	2	0	1	1	0.0	25.3	25.3
AGR	0	6	6	0	1	1	0.0	26.2	26.2
AGRON	1	212	213	1	14	15	1.2	8 59.8	9 1.0
ANS	0	116	116	0	4	4	0.0	4 14.1	4 14.1
ANTH	0	7	7	0	1	1	0.0	13.6	13.6
BECBS	0	15	15	0	1	1	0.0	8.5	8.5
BEDRE	0	14	14	0	1	1	0.0	10.6	10.6
BOT	0	59	59	0	1	1	0.0	53.6	53.6
CE	12	838	850	2	28	30	19.1	26 44.3	27 3.5
CERE	0	5	5	0	1	1	0.0	1.5	1.5
CHE	0	1339	1339	0	47	47	0.0	35 58.7	35 58.7
CRC	0	3	3	0	1	1	0.0	6.1	6.1
CSL	0	19	19	0	1	1	0.0	1 41.0	1 41.0
DCS	117	255	372	1	9	10	1 24.9	8 24.3	9 49.3
DNSTU	0	31	31	0	1	1	0.0	21.2	21.2
DS	0	180	180	0	5	5	0.0	3 2.4	3 2.4
ECON	22	21	43	3	2	5	1 7.6	26.2	1 33.9
ED	0	118	118	0	6	6	0.0	3 23.6	3 23.6
EDTES	0	6	6	0	1	1	0.0	2.5	2.5
EE	123	520	643	6	18	24	1 11.8	11 7.9	12 19.7
GENE	76	0	76	3	0	3	1 41.5	0.0	1 41.5
GEOL	0	15	15	0	2	2	0.0	12.4	12.4
GSBA	4	0	4	1	0	1	2.5	0.0	2.5
HORT	0	2	2	0	1	1	0.0	4.3	4.3
ICR	0	83	83	0	2	2	0.0	2 17.8	2 17.8
IED	0	2	2	0	1	1	0.0	2.7	2.7
IGPA	0	24	24	0	1	1	0.0	42.5	42.5
INADM	37	18	55	2	1	3	1 21.8	8.5	1 30.4
IREC	0	6	6	0	1	1	0.0	8.3	8.3
MATH	516	0	516	3	0	3	1 37.6	0.0	1 37.6
ME	249	570	819	5	23	28	2 45.1	14 59.7	17 44.9
MEDIC	0	3	3	0	1	1	0.0	20.5	20.5
MKTG	0	6	6	0	2	2	0.0	14.2	14.2

7094 Table III. February 1965 - Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	TandE[2]	Res	Total	TandE[2]	Res	Total	TandE[2]	Res	Total
MMPE	12	73	85	1	5	6	15.2	2 3.7	2 19.0
NUCE	25	228	253	3	11	14	17.8	5 9.8	5 27.7
OIR	0	130	130	0	4	4	0.0	4 31.0	4 31.0
PEM	0	12	12	0	1	1	0.0	5.1	5.1
PHYCS	5	1462	1467	1	31	32	2.6	128 59.9	129 2.6
PHYSL	0	3	3	0	1	1	0.0	0.3	0.3
PROVS	0	14	14	0	1	1	0.0	20.8	20.8
PSYCH	0	318	318	0	24	24	0.0	12 57.3	12 57.3
SCONS	0	24	24	0	2	2	0.0	50.0	50.0
SCS	0	40	40	0	1	1	0.0	1 3.7	1 3.7
SGS	0	11	11	0	1	1	0.0	5.2	5.2
SOC	0	8	8	0	1	1	0.0	6.4	6.4
SWS	0	196	196	0	15	15	0.0	6 1.9	6 1.9
TAM	54	200	254	1	7	8	34.1	5 24.4	5 58.6
VMS	0	9	9	0	1	1	0.0	1.7	1.7
VPH	0	16	16	0	1	1	0.0	35.2	35.2
WPGU	0	4	4	0	1	1	0.0	9.1	9.1
XSSS[3]	0	243	243	0	1	1	0.0	2 14.6	2 14.6
ZOOL	0	23	23	0	1	1	0.0	1 59.8	1 59.8
Subtotal	1281	7910	9191	37	314	351	12 56.9	317 2.9	329 59.9
DCSSY[4]	0	1323	1323	0	20	20	0.0	40 14.6	40 14.6
XDCS[5]	0	62	62	0	1	1	0.0	7 15.1	7 15.1
SSUAD[6]	0	635	635	0	2	2	0.0	16 20.6	16 20.6
Total	1281	9930	11211	37	337	374	12 56.9	380 53.2	393 50.2

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Improvement and Modifications
5 System Updating
6 University Administrative Overhead Use

TABLE I - IBM 1401-I

Summary of Use

March, 1965

Scheduled Engineering	3:00
Unscheduled Engineering	1:08
Maintenance	7:17
7094 Preparation	532:06
Listing	20:53
Code Checking	26:12
Tape Duplication	:12
Tape Dumping	16:32
Reproduction	27:55
Scanning Measuring Projector	25:02
Tape Testing	:15
Tape Labeling	1:15
Illiac Preparation	4:11
Idle	20:59
Total	686:57

TABLE II - IBM 1401-I

Summary of Machine Errors

March, 1965

1401 Main Frame	0
1402 Card Reader-Punch	5
1403 Printer	1
729 V Tape Drives	3
Total	9

TABLE I - IBM 1401-II

Summary of Use

March, 1965

Scheduled Engineering	5:28
Unscheduled Engineering	20:00
Maintenance	8:07
7094 Preparation	427:09
Listing	33:45
Code Checking	26:48
Tape Duplication	4:46
Tape Dumping	14:52
Reproduction	34:03
Scanning Measuring Projector	8:41
1604 Preparation	:20
Tape Testing	10:31
Tape Labeling	2:02
Illiac Preparation	4:21
Idle	31:56
Total	632:49

TABLE II - 1401-II

Summary of Machine Errors

March, 1965

1401 Main Frame	1
1402 Card Reader-Punch	6
1403 Printer	9
1406 Core Storage Unit	1
729 V Tape Drives	2
Total	19

TABLE I - IBM 7094

Summary of Use

March, 1965

Scheduled Engineering	42:17
Unscheduled Engineering	1:31
Maintenance	10:05
7094 Air Conditioning	:10
Idle	15:55
Miscellaneous (Operator training, tape rewind, tape mounting, both system and user, rerun of failing problems tape skipping, destruction of clock reading)	69:41

TOTAL USE

Training and Education			36:17
University Administrative Overhead Use			19:53
University Administrative Overhead Use (Rel)			:11
System Updating			9:34
System Modification and Improvement			24:07
System Modification and Improvement (Rel)			14:38
Customer Use			
In System		298:04	
Relinquish			
AGEC	22:21		
CHE	:09		
DCS	:45		
PHYCS	82:20		
		105:35	
Special Short Shots		1:53	
Customer Use			405:32
Total Use			510:12
Total Time On			649:51

TABLE II - IBM 7094

Summary of Machine Errors

March, 1965

7607 Data Channel	1
716 On line Printer	1
721 On Line Punch	1
729 VI Tape Drives	10
7094 Air Conditioning System	2
Miscellaneous Errors	3
Total	18

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	TandE[2]	Res	Total	TandE[2]	Res	Total	TandE[2]	Res	Total
AAE	208	211	419	3	8	11	2 26.3	6 9.2	8 35.5
ACCY	0	4	4	0	1	1	0.0	3.7	3.7
ADV	0	152	152	0	1	1	0.0	3 2.2	3 2.2
AGE	19	117	136	1	3	4	23.3	1 49.3	2 12.7
AGEC	7	302	309	1	19	20	3.1	29 36.0	29 39.2
AGR	0	1	1	0	1	1	0.0	3.9	3.9
AGREX	0	1	1	0	1	1	0.0	1.0	1.0
AGRON	0	203	203	0	18	18	0.0	8 28.9	8 28.9
ANGEN	0	1	1	0	1	1	0.0	0.1	0.1
ANS	0	81	81	0	2	2	0.0	4 13.9	4 13.9
ANTH	89	4	93	2	1	3	51.7	9.2	1 1.0
ASTR	0	42	42	0	1	1	0.0	19.9	19.9
BECBS	0	18	18	0	2	2	0.0	46.8	46.8
BEDRE	0	8	8	0	1	1	0.0	7.0	7.0
BIOPH	0	22	22	0	1	1	0.0	25.0	25.0
BOT	0	20	20	0	2	2	0.0	24.1	24.1
CE	117	1208	1325	3	32	35	1 0.1	32 7.3	33 7.5
CERE	0	35	35	0	1	1	0.0	12.2	12.2
CHE	272	1498	1770	2	52	54	1 28.7	44 54.5	46 23.3
DCS	454	207	661	2	10	12	3 42.1	6 40.8	10 23.0
DNSTU	0	9	9	0	1	1	0.0	4.4	4.4
DS	0	244	244	0	5	5	0.0	3 40.8	3 40.8
DUE	0	18	18	0	2	2	0.0	16.3	16.3
ECON	13	50	63	1	5	6	5.4	2 46.9	2 52.4
ED	3	118	121	1	6	7	1.4	3 43.6	3 45.0
EDTES	0	3	3	0	1	1	0.0	1.2	1.2
EE	294	666	960	6	20	26	2 2.8	18 38.0	20 40.9
FIN	16	0	16	1	0	1	9.5	0.0	9.5
GENE	105	0	105	2	0	2	1 39.5	0.0	1 39.5
GEOG	0	16	16	0	1	1	0.0	9.7	9.7
GEOL	0	7	7	0	2	2	0.0	2.6	2.6
GSBA	101	0	101	2	0	2	2 27.4	0.0	2 27.4
HORT	0	21	21	0	3	3	0.0	44.2	44.2
ICR	0	106	106	0	4	4	0.0	4 52.6	4 52.6
IE	55	0	55	1	0	1	12.0	0.0	12.0
IGPA	0	41	41	0	1	1	0.0	53.7	53.7
ILR	0	2	2	0	1	1	0.0	1.6	1.6
INADM	88	37	125	1	1	2	2 49.9	28.4	3 18.4
IREC	0	64	64	0	3	3	0.0	20.0	20.0
	0	3	3	0	2	2	0.0	3.8	3.8

7094 Table III. March 1965 - Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	TandE[2]	Res	Total	TandE[2]	Res	Total	TandE[2]	Res	Total
MATH	1899	0	1899	2	0	2	6 11.4	0.0	6 11.4
ME	979	853	1832	10	23	33	9 8.3	16 26.0	25 34.4
MEDIC	0	5	5	0	1	1	0.0	8.3	8.3
MKTG	0	7	7	0	1	1	0.0	23.2	23.2
MMPE	12	47	59	2	5	7	4.8	36.1	41.0
MUSIC	0	24	24	0	1	1	0.0	12.5	12.5
NUCE	38	282	320	2	10	12	18.7	8 7.0	8 25.7
OIR	0	215	215	0	4	4	0.0	7 39.5	7 39.5
PEM	0	15	15	0	1	1	0.0	14.5	14.5
PEW	0	7	7	0	1	1	0.0	24.2	24.2
PHYCS	61	2164	2225	1	32	33	20.8	156 2.8	156 23.7
PROVS	0	1	1	0	1	1	0.0	0.1	0.1
PSYCH	0	577	577	0	32	32	0.0	13 50.6	13 50.6
SCONS	0	43	43	0	2	2	0.0	53.0	53.0
SCS	0	94	94	0	1	1	0.0	2 28.0	2 28.0
SGS	0	12	12	0	1	1	0.0	4.4	4.4
SOC	11	5	16	1	2	3	5.5	8.4	13.9
SOCW	0	1	1	0	1	1	0.0	0.8	0.8
SWS	0	237	237	0	16	16	0.0	6 47.5	6 47.5
TAM	60	224	284	2	7	9	43.4	11 38.3	12 21.8
VMS	0	19	19	0	1	1	0.0	7.4	7.4
VTED	0	6	6	0	1	1	0.0	15.7	15.7
WPGU	0	6	6	0	1	1	0.0	6.6	6.6
XSSS[3]	0	246	246	0	1	1	0.0	1 53.4	1 53.4
ZOOL	0	21	21	0	1	1	0.0	36.6	36.6
Subtotal	4901	10651	15552	49	363	412	36 17.3	405 31.6	441 48.9
DCSSY[4]	0	1368	1368	0	21	21	0.0	38 45.0	38 45.0
XDCS[5]	0	63	63	0	1	1	0.0	9 33.8	9 33.8
SSUAD[6]	0	559	559	0	2	2	0.0	20 4.4	20 4.4
Total	4901	12641	17542	49	387	436	36 17.3	473 54.8	510 12.1

1 See list of departmental codes following
2 Training and Education
3 Special short shots
4 System improvement and modifications
5 System Updating
6 University Administrative Overhead

6. GENERAL LABORATORY INFORMATION

6.1 Colloquia

"Some Computer Time-Sharing Ideas," by Professor David J. Kuck, Assistant Professor of Electrical Engineering at Massachusetts Institute of Technology, Cambridge, Massachusetts, March 8, 1965.

"Use of the Computer in the Study of Complex Ions," by Dr. H. G. Friedman, Department of Computer Science, University of Illinois, Urbana, Illinois, March 15, 1965.

"Automatic On-Line Diagnosis of an Electronic Switching System," by Mr. Herbert Y. Chang, Bell Telephone Laboratories, Holmdel, New Jersey, March 22, 1965.

"Finite Difference Equations with Variable Coefficients," by Professor Donald G. Aronson, University of Minnesota, Minneapolis, Minnesota, March 29, 1965.

6.2 Personnel

The number of people associated with the Laboratory in various capacities is given in the following table:

	Full-time	Part-time	Full-time Equivalent
Faculty	16	3	17.33
Visiting Faculty	2	0	2.0
Research Associates	1	0	1.0
Graduate Research Assistants	6	58	35.33
Graduate Teaching Assistants	0	3	1.25
Professional Personnel	4	2	5.0
Administrative and Clerical	14	1	14.5
Other Nonacademic Personnel	55	128	109.0
TOTAL	98	195	185.41

The Computer Advisory Committee consists of Professors P. G. Braunfeld, H. C. Brearley, R. M. Brown, J. R. Ehrman, L. G. Fosdick, H. G. Friedman, Jr., C. W. Gear, D. B. Gillies, N. T. Hamilton, B. H. McCormick, G. A. Metze, S. Muroga, T. A. Murrell, J. R. Pasta, W. J. Poppelbaum, S. R. Ray, J. E. Robertson, K. C. Smith and J. N. Snyder.

6.3 Drafting

During the quarter, a total of 448 drawings were processed by both drafting sections.

	General and ILLIAC II	Pattern Recognition
Large Drawings	37	2
Medium Drawings	13	43
Small Drawings	6	50
Report Drawings (415)	6	0
Report Drawings (Task 15)	40	0
Report Drawings (1018)	0	42
ESTPG	48	0
Math 195	4	0
Layouts	0	13
Change Orders	58	8
Miscellaneous	78	0
TOTAL	290	158

(K. Law, A. Prendergast)

6.4 Shops' Production

Job orders processed and completed during the period of January 1 through March 31, 1965, are as follows:

Facility	AEC 415	AEC 1018	Other
Machine Shop	28	76	0
Electronic Shop	85	70	3
Etch Shop	25	49	3
Layout Shop	15	12	3

Etched card wiring of 387 standard printed circuit boards and 9,275 baby boards accounted for 127,890 diodes and 20,900 transistors.

6.5 Component Testing

New semiconductors tested during the period of January 1 through March 31, 1965,are as follows:

		AEC 415	AEC 1018
2N1305		400	
S16172			30,000
2N964		1,000	
SM5334			1,000
2N2219		200	
GM0532C		6,800	
G 767			3,400
G1140			50,000
G 713		1,000	
S 593			8,000
HMN9008			85,000
IN748			5,000
IN748			3,500
IN746		1,500	
IN758		500	
IN754		500	
IN749		1,000	
Assorted 415/1018	1,492		
TOTALS	1,492	12,900	185,900

10.84
L6t
Physics

COO-415-1053
COO-1469-0010
COO-1018-1062

QUARTERLY TECHNICAL PROGRESS REPORT

April, May, June 1965

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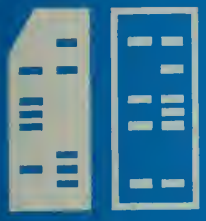

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DEPARTMENT OF COMPUTER SCIENCE · UNIVERSITY OF ILLINOIS · URBANA, ILLINOIS

VERTICAL FILE

QUARTERLY TECHNICAL PROGRESS REPORT

April, May, June 1965

Department of Computer Science
University of Illinois
Urbana, Illinois

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1. CIRCUIT RESEARCH PROGRAM

(Supported in part by the Office of Naval Research under Contract Nonr-1834(15).

1.1 Summary

As in previous months there were three main areas of research: The Paramatrix System (Michael Faiman, David Casasent, Edward Carr, Edward Prozeller the Electro-Optical work (Steven Whiteside, Dick Koo) and the "Noise Computer" (Chushin Afuso).

The Paramatrix System has begun to take shape physically and sub-sections like the scanning and setting mechanism of the display matrix have been operated successfully. The digital logic and much of the analog gating circuitry is in the process of being checked out.

The Electro-Optical work has suffered some setbacks due to the practic difficulties of attaching leads to the junctions in the Keldysh-Effect and the high absorption of the crystal. Remedies are being found presently.

The "Noise Computer" project has progressed very satisfactorily. In particular a new method of controlling the average frequency of the random sequences has been found.

1.2 Summary of Paramatrix System

Paramatrix is a combined analog and digital system for pre-processing line drawings. Its objectives are twofold: first, to perform such linear transformations on a given input picture as translation, scaling and rotation; second, to correct two common types of imperfection in line drawings, namely, thin out blur and fill in gaps. (See last Quarterly Report.)

These operations are performed speedily, almost simultaneously and to sufficient accuracy by analog methods under the control of a digital sub-system which also prepares the transformed picture for input to a digital computer. In the present model this picture is displayed on a 32 × 32 matrix of lamps.

If (x,y) denotes a point of the input picture--line drawing--and (X,Y) the corresponding transformed point of the output picture--display matrix, the linear transformations can be written as

$$X = \left(\frac{x-a}{m}\right) \cos\theta + \left(\frac{y-b}{n}\right) \sin\theta;$$

$$Y = -\left(\frac{x-a}{m}\right) \sin\theta + \left(\frac{y-b}{n}\right) \cos\theta.$$

Rather than do this, the Paramatrix scans the (X,Y) field in a quantized sequence (X_i, Y_j), the suffixes indicating the succession of steps--$0 \leq i,j \leq 31$--and generates the inverse quantities:

$$x_{ij} = m(X_i \cos\theta - Y_j \cos\theta) + a;$$

$$y_{ij} = n(X_i \sin\theta + Y_j \cos\theta) + b;$$

and at each step compares (x_{ij}, y_{ij}) with the input picture. Agreement is registered by lighting a matrix lamp. There are two reasons for this procedure. First, the transformed picture is always generated (presented for input to a computer) in the same sense, regardless of the magnitudes of a,b,m,n and θ. Second, the operations of gap filling and blur thinning can be more easily carried out.

At the present time Paramatrix looks at simulated line-drawings in the form of four rows of potentiometers which generate the (analog) voltages $f_\ell(x_k)$--$0 \leq k \leq 31$; $1 \leq l \leq 4$. There are 32 potentiometers in each row, numbered by the suffix k and the row is denoted by the suffix ℓ. A series of 32 reference voltages suffice to generate the fixed x_k.

During one clock pulse time the following operations occur, essentially in parallel:

a) The digital subsystem decodes a pair of gating signals gX_i and gY_j on to two sets of 32 wires. These are used both to select the matrix point (X_i, Y_j) and to drive the transformer.

b) The transformer performs two functions. In the first place, it does the digital to analog conversion: $gX_i, gY_j \rightarrow X_i, Y_j$. Second, it produces at its output terminals the quantities x_{ij} and y_{ij} described above.

c) One of these quantities only, x_{ij}, is fed to the Interpolator, which compares it simultaneously with the $32x_k$. The comparison circuits have a sensitivity which is adjustable manually or by program in such a way that not only is the output $f_\ell(x_{ij})$ the best linear fit to the input function $f_\ell(x_k)$, but also piecewise gaps in the input function can be generated where $f_\ell(x_k)$ is locally nonexistent (gap filling).

d) The four voltages, $f_\ell(x_{ij})$, are examined by a network of comparison circuits--adjustable like those in the Interpolator--in the Thinner. If two or more of these are sufficiently close, they are replaced by an averaged voltage, thereby accomplishing the thinning process.

e) A final comparison, in the Coincidence Unit, of the "thinned" voltages $f'_\ell(x_{ij})$ with y_{ij} from the transformer determines whether or not the lamp at (X_i, Y_j) should be lit.

1.2.1 Hybrid Circuits for Paramatrix

In the last quarterly report all of the circuits of the Paramatrix System were described and the schematics given. In this report the Paramatrix hybrid circuits will be discussed from a more theoretical viewpoint in order to make the circuit schematics more meaningful.

1.2.1.1 Constant-Current Bias Theory of the Diamond Gate

Because of the unusually large signal swings required in the Paramatrix System, it became necessary to bias the diamond gate circuits in the constant-current mode.

Assuming a constant-current bias I_0 and an exponential V-i characteristic for the bridge diodes, it is possible to derive an equation for the bridge offset ΔV, as a function of the bias current I_0 and the signal current i_s. Consider the circuit of Fig. 1. Under the above assumption, each of the diodes obeys the equation

$$I_j = I_{sj}(e^{qV_j/KT} - 1) \qquad j = 1,2,3,4$$

or

$$V_j = \frac{KT}{q} \ln(1 + \frac{I_j}{I_{sj}}) \tag{1}$$

Writing $I_1 = i$, it follows that $I_2 = i_s + i$, $I_3 = I_0 - i$ and $I_4 = I_0 - i_s - i$, as shown. The condition that $V_1 + V_2 = V_3 + V_4$ gives, from Eq. (1)

$$(1 + \frac{i}{I_{s1}})(1 + \frac{i_s + i}{I_{s2}}) = (1 + \frac{I_0 - i}{I_{s3}})(1 + \frac{I_0 - i_s - i}{I_{s4}}) \tag{2}$$

It is most instructive to consider the solution of Eq. (2) when all diodes are identical, i.e., when $I_{s1} = I_{s2} = I_{s3} = I_{s4}$. The quadratic term in Eq. (2) then drops out and the unique solution is

$$i = \frac{1}{2}(I_0 - i_s) \tag{3}$$

Thus $I_1 = I_4 = \frac{1}{2}(I_0 - i_s)$ and $I_2 = I_3 = \frac{1}{2}(i_s + I_0)$. (4)

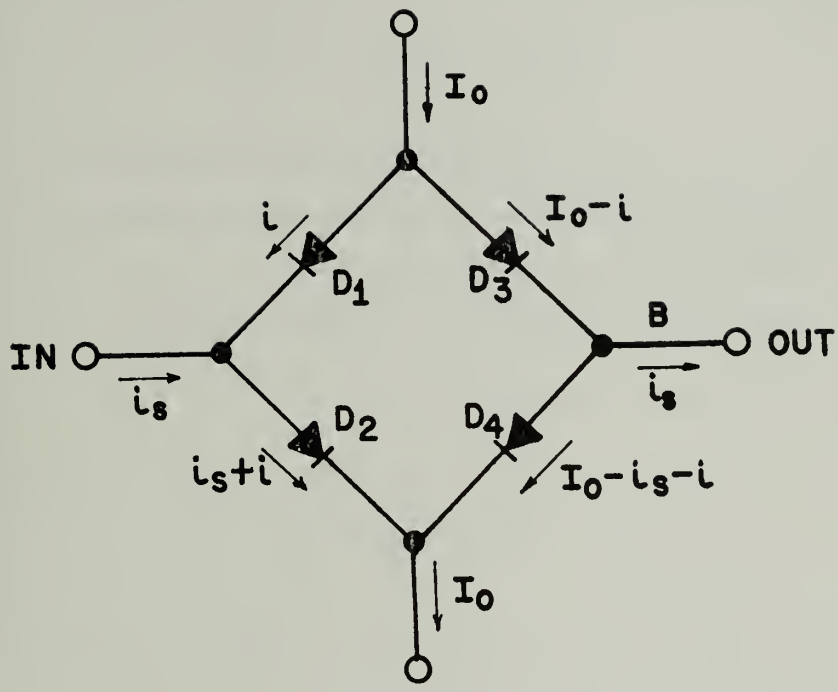


Figure 1. Analog Gate With Constant-Current Bias

It is also interesting to note that if each diode is assumed to have a small series ohmic resistance r, Eq. (1) would be replaced by

$$V_j = \frac{KT}{q} \ln\left(1 + \frac{I_j}{I_{sj}}\right) + rI_j \tag{5}$$

The solutions still hold for identical diodes and Eq. (5) is probably a more realistic equation for a real diode.

We are mainly interested in the voltage offset ΔV which, becomes,

$$\Delta V = V_3 - V_1 = V_4 - V_2 \tag{6}$$

It is convenient here to make two approximations:

a) that $I_0 - |i_s| \gg I_s$, which is almost certain to be true if all diodes are forward biassed;

b) that $i_s \ll I_0$, which may or may not be true.

Then from Eqs. (5) and (6) and (a)

$$\Delta V = \frac{KT}{q} \ln\left(\frac{I_0 + i_s}{I_0 - i_s}\right) + ri_s \tag{7}$$

If (b) is also true, Eq. (7) can be simplified still further since,

$$\ell n\left(\frac{I_0 + i_s}{I_0 - i_s}\right) \simeq \ln\left(1 + \frac{2\, i_s}{I_0 - i_s}\right) \simeq \frac{2\, i_s}{I_0} \tag{8}$$

Thus Eq. (7) becomes

$$\Delta V \simeq \left(\frac{2KT}{qI_0} + r\right) i_s \tag{9}$$

It is useful to define a figure of merit for the circuit with constant-current bias namely:

$$R_{\Diamond} \simeq \frac{\Delta V}{i_s} \simeq \frac{2KT}{qI_0} + r = \text{constant} \qquad (10)$$

It will be noted that this figure of merit is in ohms and is equal to the magnitude of offset voltage divided by the load current (load current equals signal current when constant-current bias is used). Obviously, the lower the figure of merit, the better the diamond.

1.2.1.2 Use of the Diamond Gate for Paramatrix

In the final diamond gate designed for the Paramatrix System, shown in Fig. 2, the quiescent bridge current, I_0, is 15 ma. The results of a static test of this circuit are given in Table 1 and plotted in Fig. 3.* The figure of merit, $R_{\Diamond}$, for this design is

$$R_{\Diamond} = \frac{\Delta V - \Delta V_0}{i_s} = \frac{76}{9} = 8.2\ \Omega$$

Table 1. Static Test Data For I_0 = 15 ma.

i_s (ma)	0	1	2	3	4	5	6	7	8	9
Δ V(mV)	5	14	22	31	40	48	56	65	74	81

* A quiescent offset ΔV_0 exists because the bridge diodes are not perfectly matched.

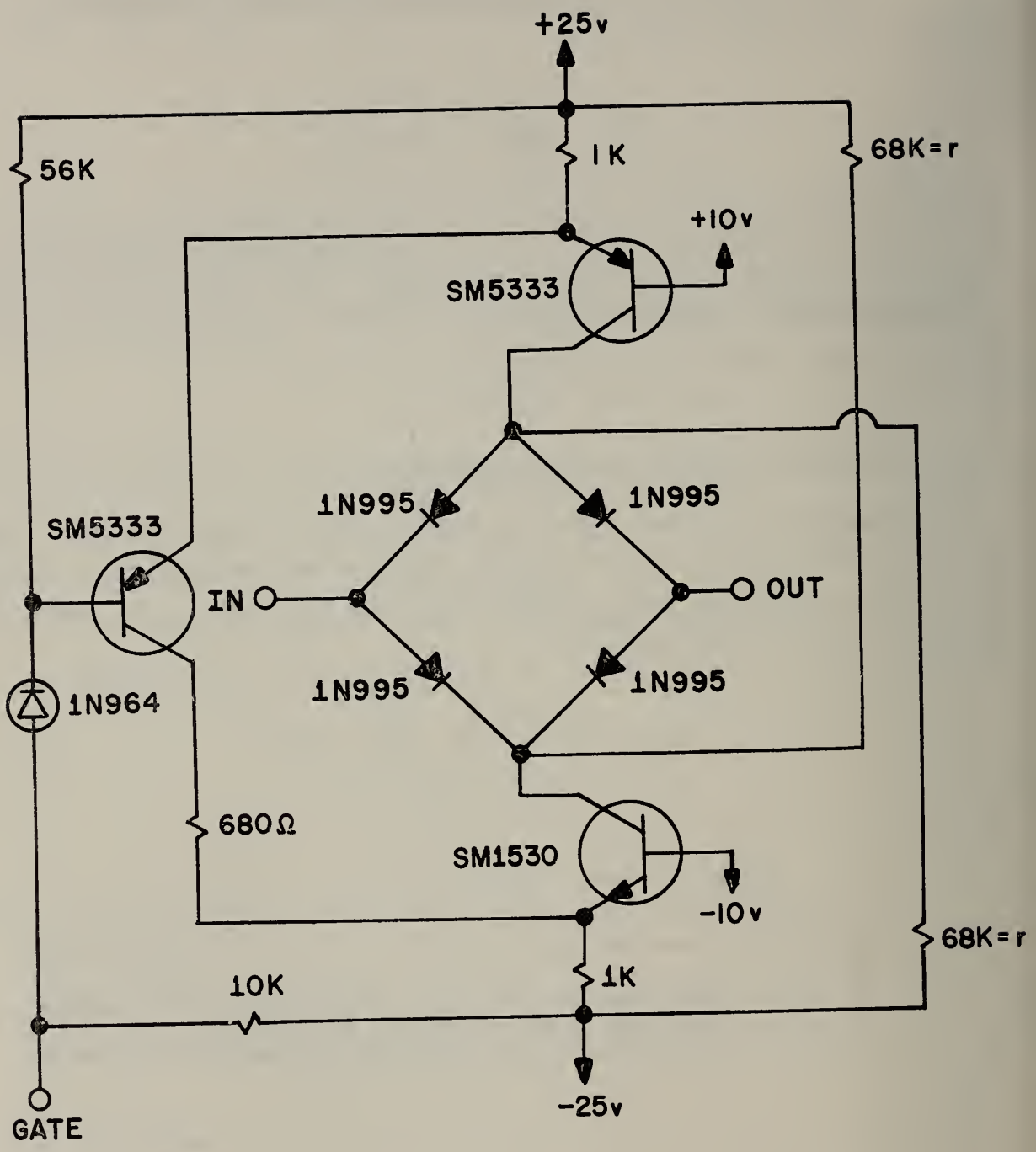


Figure 2. Diamond Gate for Paramatrix

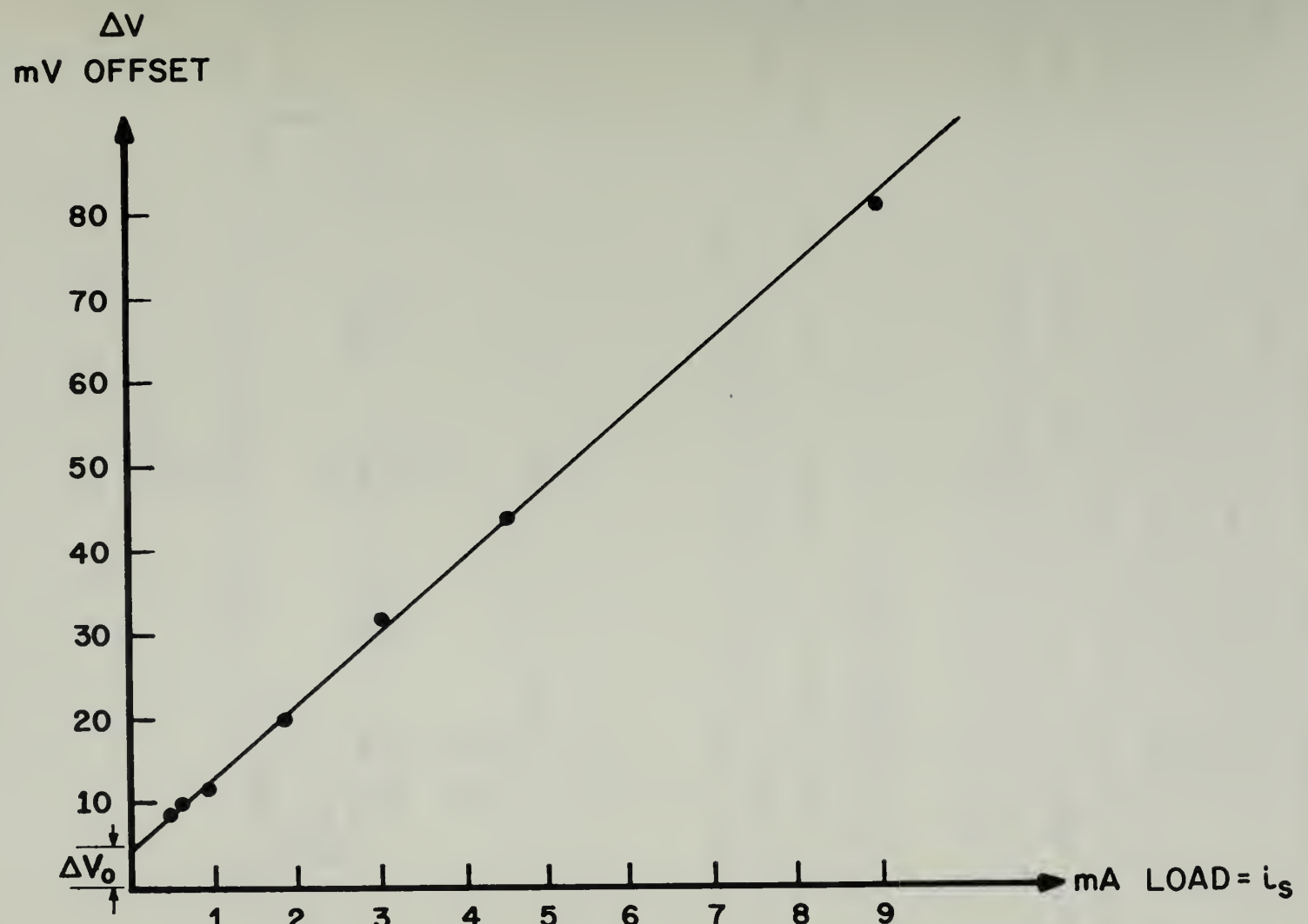


Figure 3. Diamond Response

It is interesting to note that if we use Eq. (10) with r = 0, and $\frac{KT}{q} = \frac{1}{40}$, then the ideal figure of merit for I_0 = 15 ma is r = 6 Ω which, considering the approximations involved in the derivation, is a fairly good comparison.

The dynamic performance of the diamond is quite good. The rise time of the circuit is mainly a function of the bridge resistance and the junction capacitances of the bridge diodes and T_1 and T_2. Since the bridge resistance is very small the rise times are quite fast, typically on the order of 40 ns. The fall times however are a function of the junction capacitance and the output resistance of the bridge which is usually 1 to 2 K. As a result the fall times are slower, typically 100 ns for a 1 K load. The addition of resistors, r, to the circuit have the effect of back-biasing the bridge when the bias current is removed and results in a faster fall time.

1.2.1.3 Comparator Circuit Theory

In order to derive the comparator circuit equations, the circuit of Fig. 4 will be analyzed, assuming ideal transistors and diodes. The analysis becomes somewhat simpler if the emitter currents are defined as

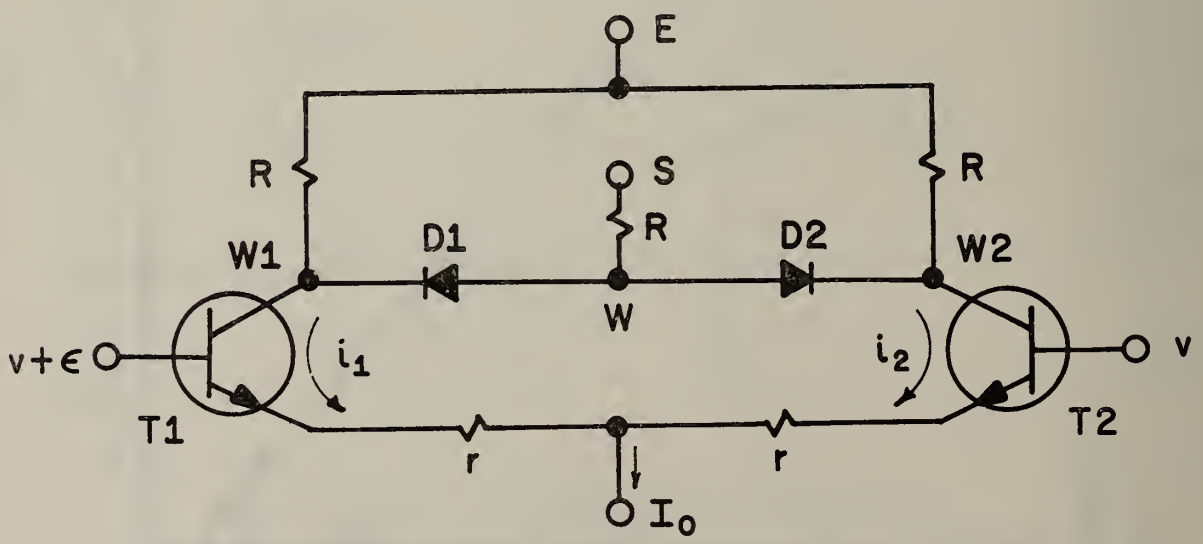


Figure 4. Modified Difference Amplifier

$$i_1 = \frac{1}{2}(I_0 + i)$$

$$i_2 = \frac{1}{2}(I_0 - i)$$

and hence, $\epsilon = ri$.

Now with $\epsilon > 0$ we assumed D_1 on and D_2 off, so that

$$w = w_1 < w_2$$

then writing KCL equations at w_1, we have

$$\frac{1}{2}(I_0 + i) = \frac{1}{2}(I_0 + \epsilon/r) = \frac{E - w_1}{R} + \frac{S - w_1}{R}$$

or

$$w_1 = w = \frac{1}{2}(E + S) - \frac{1}{4}R(I_0 + \epsilon/r) \tag{11}$$

Thus if it were true that only one diode were on, w as a function of $\eta = |\epsilon|$ and S would appear as shown in Fig. 5. The sensitivity selection property of the modified circuit is obvious. Of course it is not always true that only one diode is on at a time; with $\eta = 0$ both diodes are on. Then $w = w_0$, say, which is given by

$$I_0 = \frac{2E + S - 3v_0}{R},$$

or

$$w_0 = \frac{1}{3}(2E + S - RI_0) \tag{12}$$

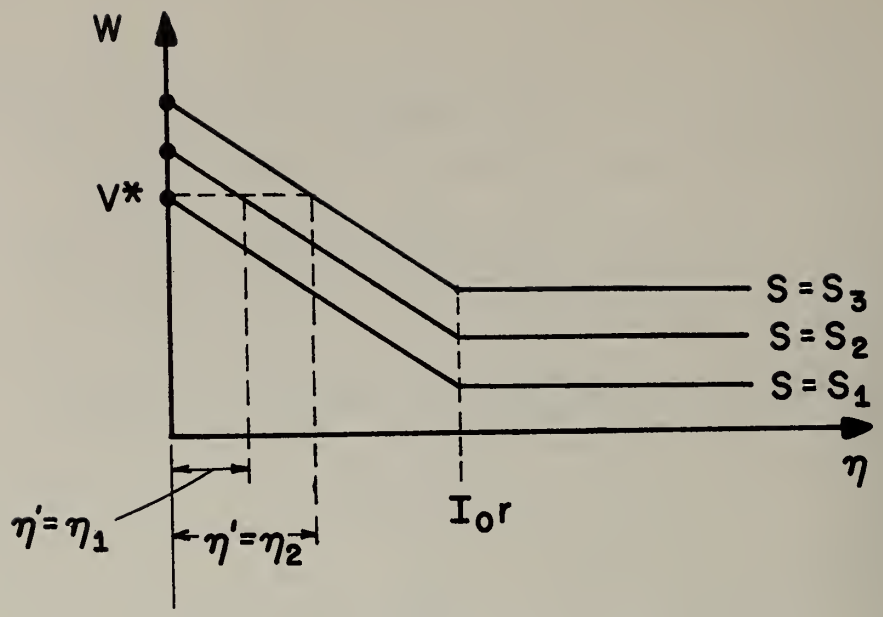


Figure 5. Modified Differential Amplifier Response

Depending on the magnitude of S, w_0 can be either greater or less than the limit of w as $\epsilon \to 0$ in Eq. (11). Furthermore, let us calculate w_2 on the assumption that D_2 is off:

$$\frac{1}{2}(I_0 - i) = \frac{1}{2}(I_0 - \epsilon/r) = \frac{E - w_2}{R}$$

or

$$w_2 = E - \frac{1}{2} R(I_0 - \epsilon/r).$$

Then

$$w_2 - w_1 = \frac{1}{2}(E - S) - \frac{1}{4} R(I_0 - \frac{3\epsilon}{r}) \qquad (13)$$

which shows that, if $\epsilon < \frac{1}{3} r I_0$ and (E - S) is small enough, it is not necessarily true that $w_2 > w_1$. In this case we have $w_1 = w_2 = w_0$, even though $\eta \neq 0$.

1.2.1.4 Specific Requirements for Comparator Circuit

We must now choose some threshold voltage V* from the range of possible values of w and make the definitions $w > V^*$ means coincidence and $w < V^*$ means noncoincidence. Then varying S alters the value of η' (for all $\eta < \eta'$ the inputs are the same) and hence provides our sensitivity selection.

It is convenient to set $S_{max} = E$ and $S_{min} = V^*$. We also require that, for $S = E$ and $\epsilon = rI_0$, $w = V^*$. Hence from Eq. (11)

$$V^* = \frac{1}{2}(E + E) - \frac{1}{4} R(I_0 + I_0)$$

or

$$RI_0 = 2(E - V^*) \tag{14}$$

We notice that, for $S = V^*$ and RI_0 given by Eq. (14), Eq. (12) gives

$$w_0 = \frac{1}{3}(2E + w - 2E + 2w) = w$$

which is due to choosing the sensitivity resistor equal to the collector resistors.

Finally substitution of Eq. (14) in Eq. (13) gives

$$w_2 - w_1 = (\frac{3R}{4r}) \epsilon - \frac{1}{2}(S - V^*)$$

Hence the on-off diode condition is satisfied if

$$\eta > \frac{2r}{3R} (S - V^*) \tag{15}$$

1.2.1.5 Analog Comparator for Paramatrix

The comparator circuit which was designed for the Paramatrix System is shown in Fig. 6. For this circuit the emitter of T_3 is tied to the threshold voltage V* = 10v and the digitial output signal is taken off of the collector of T_4. Hence for coincidence w > 10v and v_0 = 0v; for noncoincidence w < 10v and v_0 = -5v. We also have from Eq. (12)

$$w_0 = \frac{1}{3}(20 + S)$$

if both diodes are on. From Eq. (15) for only one diode on we have

$$w = 5 + \frac{1}{2} S - 3.75\eta \tag{16}$$

and finally for Eq. (16) to be true we require that

$$\eta > \frac{2}{45}(S - 10). \tag{17}$$

These results are illustrated graphically in Fig. 7. It will be noticed that the case of both diodes conducting ($w = w_0$) for noncoincident input signals, occurs only at S = 10v, i.e., $\eta' = 0$.

The circuit of Fig. 6 approaches quite closely the characteristics of Fig. 7 except at the extremes of the sensitivity voltage S where we would expect the real curves to be quite rounded. The experimental sensitivity data for the Paramatrix Comparator is given in Table 2.

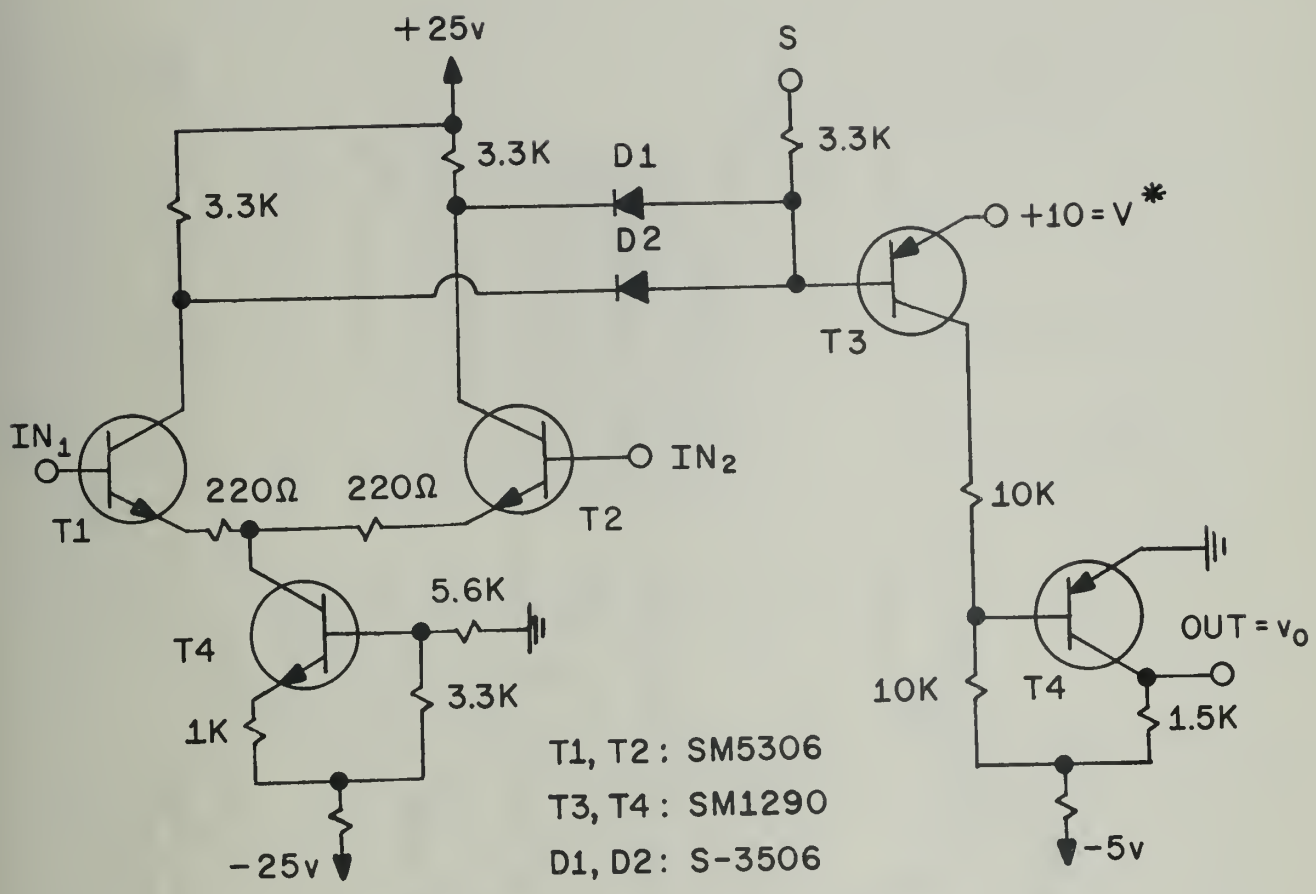


Figure 6. Parmatrix Comparator

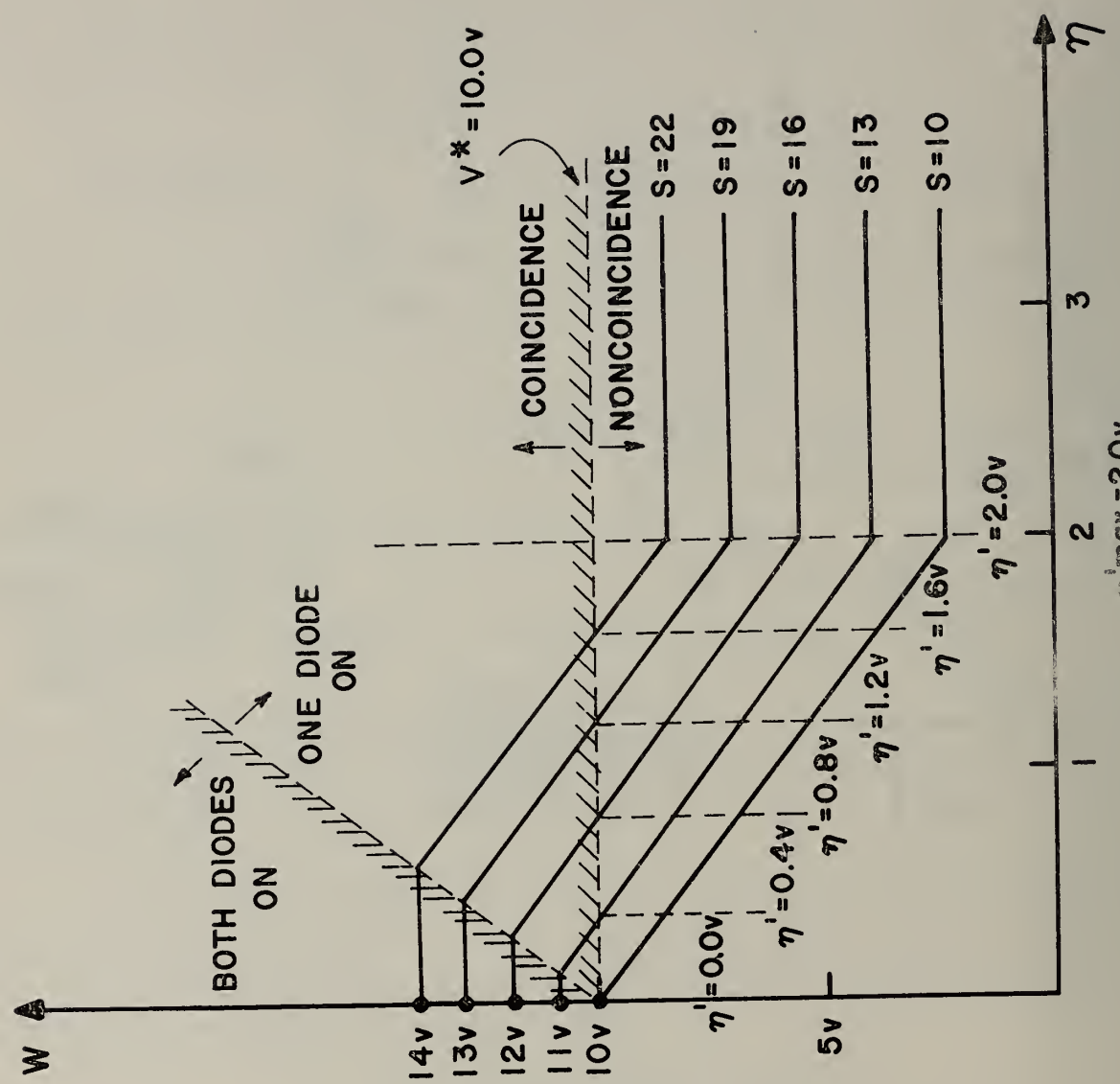


Figure 7. Ideal Comparator Characteristics

TABLE 2.

EXPERIMENTAL DATA FOR PARAMATRIX COMPARATOR

S	η'
10v	No coincidence
12v	0.2v
13v	0.38v
16v	0.78v
19v	1.25v
22v	1.65v
24v	2.0v
25v	No noncoincidence

1.2.2 Transformer Circuits for Paramatrix

1.2.2.1 Method of Transformation

The voltages which designate the x and y coordinates under investigation were chosen so that they would be symmetric about the origin of the matrix, the (0 volt, 0 volt) coordinate. This makes the operation of magnification one of simply multiplying each x_i and y_i coordinate value by the magnification factor desired. This implies that for magnification, as well as rotation, the figure be centered at the matrix origin.

In transforming a figure, the following order is the one which will yield the desired results most easily:

a) Translation until the geometric center of the figure lies at the matrix origin,

b) Magnification, and

c) Rotation.

By definition:

x_{ij}, y_{ij} are the initial coordinates of the figure
x_i, y_j are the transformed coordinates of the figure
a is the amount of translation in the x direction

b is the amount of translation in the y direction

θ is the angle of rotation

m is the magnification factor in the x direction

n is the magnification factor in the y direction.

The transformer, however, inspects each of the 1024 matrix points (X_i, Y_j) i,j = 0 ... 31 and determines what initial matrix point with the given values of a, b, θ, m and n would have generated the point in question. In other words, the inputs to the transformer are X_i and Y_j, the transformed coordinates, and the outputs are x_{ij} and y_{ij}, the initial coordinates. Depending on whether the generated matrix intersection, (x_{ij}, y_{ij}), was activated on the initial figure, the corresponding transformed point, (X_i, Y_j), will be activated or left alone. The following intersection, (X_i, Y_{j+1}), is then similarly inspected and the process continues until the entire matrix has been scanned. This method of transformation is the simplest to implement in hardware.

The equations of transformation that the transformer solves correspond to performing the inverse operation done on the matrix and in the opposite order. The order of the operations that the transformer performs is: counterclockwise rotation, demagnification, and negative translation. The equations of transformation are

$$x_{ij} = \frac{1}{m}[X_i \cos\theta - Y_j \sin\theta\ ] - a$$

$$y_{ij} = \frac{1}{n}[X_i \sin\theta + Y_j \cos\theta] - b$$

$$ij = 0 \ldots 31$$

where X_i and Y_j assume all 1024 possible combinations of 32X and 32Y coordinates. If the order of magnification and rotation were reversed the common factors, $\frac{1}{m}$ and $\frac{1}{n}$, would not appear and the equations would be more difficult to generate.

1.2.2.2 Generation of Equations of Transformation

Figure 8 shows the generation of these equations. $\pm v \sin\theta$ and $\pm v \cos\theta$ are the outputs of a sine-cosine potentiometer. The resistance chain of 32 equal resistors and 32 diamond gates with appropriate gate signals provides the four trigonometric terms in the equations of transformation with appropriate signs included. Since these four terms occur as the outputs of diamond gate circuits which are passive elements, four current amplifiers must be used:

By definition:

K = resistive summing network coefficient, or the fraction of the sum of the input voltages which appears at the output.

G = gain of the voltage amplifier

$K_{1x} = \frac{2.2}{Gm}$ = K for first stage x_{ij} network

$K_{1y} = \frac{2.2}{Gn}$ = K for first stage y_{ij} network

$K_{2x} = \frac{1}{2.2}$ = K for second stage x_{ij} network

$K_{2y} = \frac{1}{2.2}$ = K for second stage y_{ij} network

The voltages in Fig. 2 are thus:

$$V_{1x} = K_{1x} (X \cos\theta - Y \sin\theta)$$
$$V_{1y} = K_{1x}(X \sin\theta + Y \cos\theta)$$
$$V_{2x} = K_{2x}(V_{1x} - K_{1x}\, ma)$$
$$V_{2y} = K_{2y}(V_{1y} - K_{1y}\, nb)$$

Therefore x_{ij} and y_{ij} have the values defined above.

The two analog circuits of Fig. 8, the current amplifier and the voltage amplifier are presented in Figs. 9 and 10.

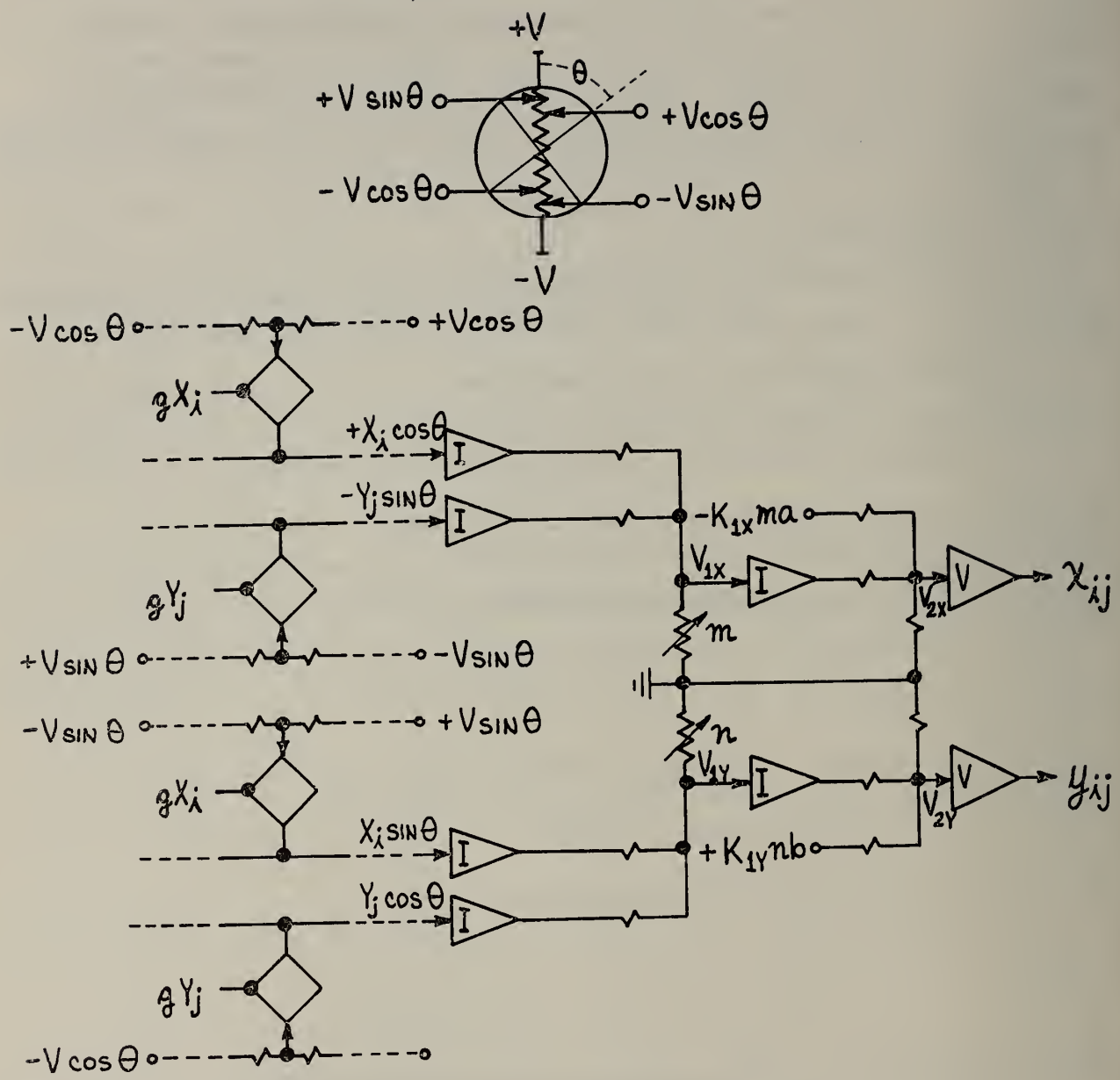


Figure 8. Paramatrix Transformer

1.2.2.3 Current Amplifier

The ideal current amplifier would have infinite current gain with zero offset voltage. A conventional emitter-follower gives a current gain of about β and an offset voltage equal to the emitter-base junction drop. A current gain of β is satisfactory but the emitter-base junction drop is far too large an offset for Paramatrix applications and hence it is necessary to design a compensated circuit.

The current amplifier is shown in Fig. 9. T_1 is a constant-current source and T_7 a constant-current sink, thus the current in T_2 is constant and V_{eb2} is constant. T_5 and T_6 are a difference amplifier connected between input and output with feedback to reduce any offset. If the output is above the input T_6 passes more current and the bases of T_3 and T_4 are lowered, thus lowering the output. Similarly, if the output is below the input, T_6 passes less current and the bases of T_3 and T_4 are raised thus raising the output. The output transistors T_3 and T_4 enable this circuit to provide or receive current. Only one output transistor is on at a time depending on whether the output is positive or negative. It is only necessary to compensate for the difference in junction drops in T_2 and T_3 or T_4 (whichever is conducting). The difference amplifier adjusts the voltage drop across R_1 to compensate for any difference which may exist. The 10 K pot is used to obtain zero offset initially. The output voltage range is restricted to $-10 \leq V_{out} \leq +10$ volts by the collector supplies of T_3 and T_4.

1.2.2.4 Specifications of Voltage Amplifier

Since a resistive summing network can never give gain, a voltage amplifier is necessary to bring the voltages of Fig. 8 into the range used in the Paramatrix System. The voltage amplifier of Fig. 10 has the following specifications:

a) open loop gain = 107
b) closed loop gain $\simeq$ 21
c) gain constant within 0.33%
d) output range $-10 \leq V_{out} \leq +10$ volts
e) maximum drift = 8 mv
f) maximum offset = 8 mv

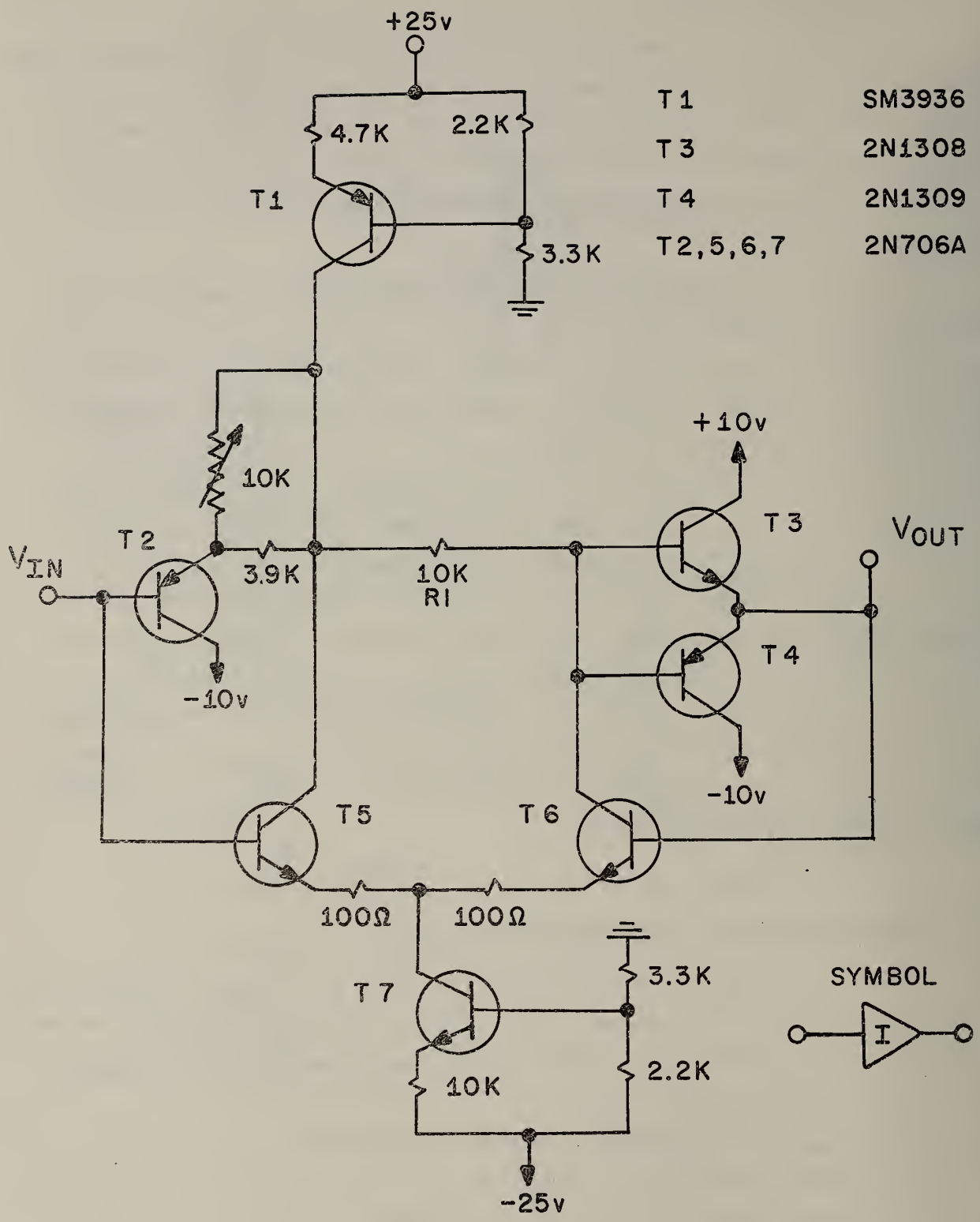
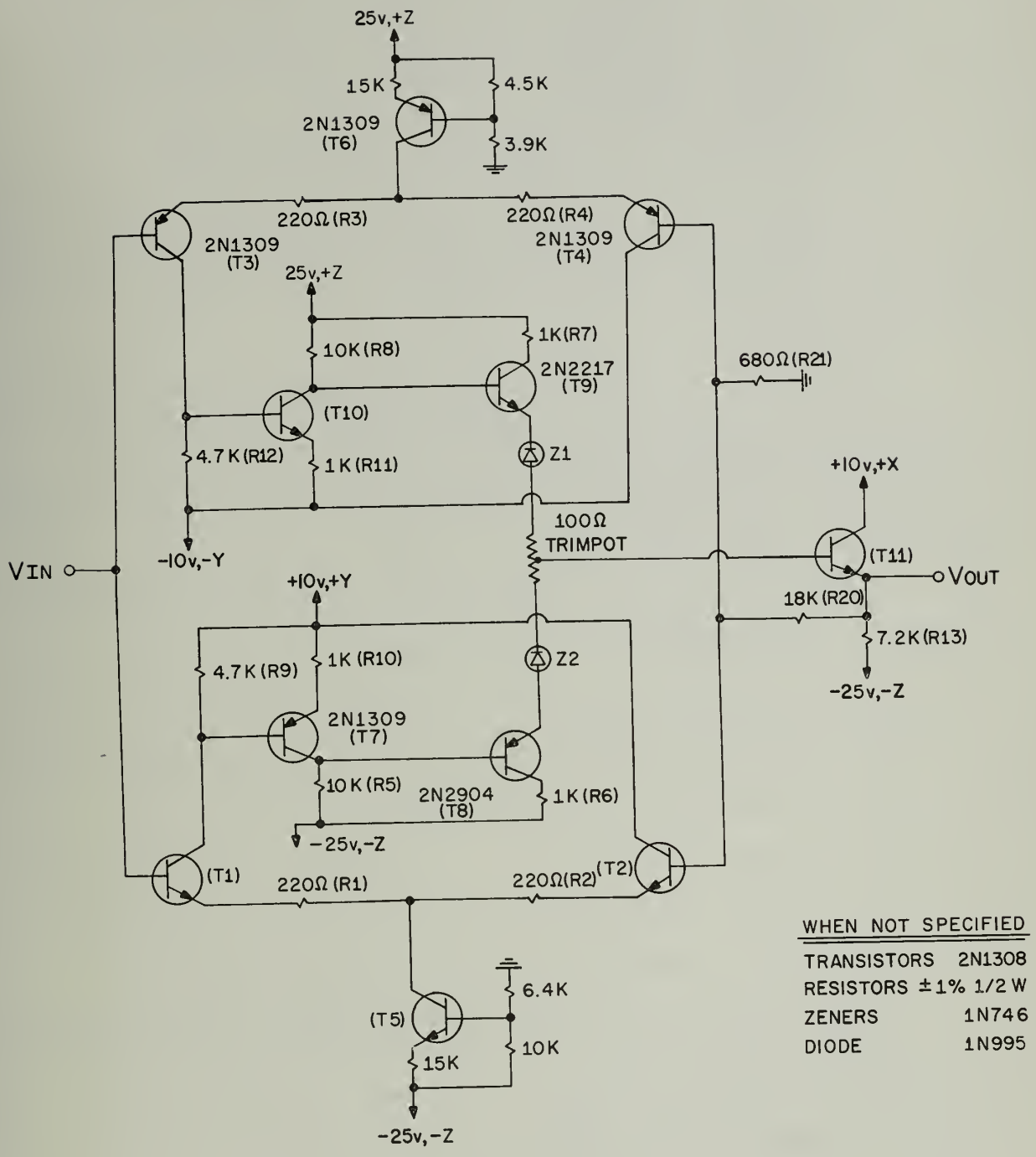


Figure 9. Current Amplifier Circuit



WHEN NOT SPECIFIED	
TRANSISTORS	2N1308
RESISTORS	±1% 1/2 W
ZENERS	1N746
DIODE	1N995

Figure 10. Ultralinear Voltage Amplifier

g) maximum load current = 10 ma at all voltages

h) maximum loading error = 15 mv

i) frequency range of dc to 1 mc (with square wave input and silicon transistors)

j) interchange of components with no loss of accuracy.

This amplifier is essentially two voltage amplifiers feeding a constant-current pre-output stage which feeds an emitter-follower whose output is fed back to the input stages. The feedback is such as to correct any nonlinearities in the circuit gain.

The circuits' low drift is due to the topology and the positioning of the operating point on the power dissipation curves which enables them to be linearized. The ultralinearity of the gain is due to the topology and to the positioning of the operating point on the V_{eb} versus i_c curves which enables them to be linearized.

For the analysis of the voltage amplifier, the following definitions and assumptions are employed:

$\alpha = 1$

V_n = voltage at the base of T_n

P_n = collector power dissipation of T_n

i_n = collector current of T_n

I_n = constant current i_n

T'_n = junction temperature of T_n

$V_{ebm}(i_n)$ means i_n is the current to which V_{ebm} is directly proportional

$|V_{eb}| = V_{eb}$

f = feedback ratio = $\dfrac{R_{21}}{R_{20} + R_{21}}$

G_0 = open loop gain = $\frac{R_8 R_{12}}{R_{11}(R_3 + R_4)} = \frac{R_5 R_9}{R_{10}(R_1+R_2)}$

G = closed loop gain = $\frac{G_0}{1+fG_0}$

∂X = change in X

$V'_{out} = fV_{out}$

Zero offset is V_{out} for $V_{in} = 0$

$\partial(V_9 - V_8)$ = deviation in (V_9-V_8) from its initial value at zero offset

1.2.2.5 Constant-Current Pre-Output Stage

V_8 and V_9 are the outputs of two similar two-stage amplifiers with approximately equal gains. As V_8 increases or decreases, V_9 increases or decreases by the same amount. Thus i_8, i_9, V_{R22}, V_{eb8}, V_{eb9}, V_{z1}, and V_{z2} are nearly constant even though V_{11} has a 20 volt range, $-10 \leq V_{11} \leq 10$ volts. The zero offset condition on V_8 and V_9 are chosen such that $V_{R22} \approx 1v$. This voltage is sufficient to allow replacement of components since it is only necessary that the value $V_{11} \approx 0.2$ volts at $V_{in} = 0$ be included in the 1 volt range of V_{R22}. The constancy of these pre-output parameters increases the circuit's accuracy greatly.

1.2.2.6 D-C Analysis

For $V_{R22} \approx 1v$ the zero offset conditions are:

$$V_8 \approx V_{eb11} - \frac{1}{2} V_{R22} - V_{z2} - V_{eb8} \approx -4v$$

$$V_9 \approx V_{eb11} + \frac{1}{2} V_{R22} + V_{z1} + V_{eb9} \approx +4v$$

The conditions for linearity of operation in the range $-x \leq V_{out} \leq +x$ are:

Referring to the notation used in Fig. 10 we must have

$$Z > X - \frac{G_0}{G} 4$$

$$i_1 = \frac{Z-4}{R_2 G_0}$$

$$\frac{R_9}{R_1+R_2} \left[\frac{X}{G_0} + 4f + \frac{Z}{G_0}\right] < \text{Minimum of } \left[Y - X + 4, \frac{R_9(Z-4)}{R_2 G_0}\right]$$

$$(X+Z+4fG_0) < (Z-4)\left(1 + \frac{R_1}{R_2}\right)$$

$$(X+Z+4fG_0) \frac{R_{10}}{R_5} < Y-X+4$$

Similar relations hold for the second two-stage amplifier.

1.2.2.7 Effect of Nonthermal V_{eb} Variations

For $\partial V_{in} > 0$, i_1, i_7, V_8, and V_9 increase and i_3 and i_{10} decrease. For $\partial V_{in} < 0$ i_1, i_7, V_8, and V_9 decrease and i_3 and i_{10} increase. Considering only V_{eb} variations due to current, the voltage at V_8 can be written as

$$V_8 = \frac{R_5 R_9}{R_{10}} \left[\frac{I_5}{2} - \frac{V'_{out}}{R_1+R_2} + \frac{V_{in}}{R_1+R_2} + \frac{V_{eb2}(-i_1) - V_{eb1}(i_1)}{R_1 + R_2} \right] - \frac{R_5}{R_{10}} V_{eb7}(i_7) - 25v$$

or

$$\partial V_8 = \frac{R_5 R_9}{R_{10}(R_1+R_2} \left[\partial V_{in} - \partial V'_{out} + \partial V_{eb2}(-i_1) - \partial V_{eb1}(i_1) \right] - \frac{R_5}{R_{10}} \partial V_{eb7}(i_7).$$

With the assigned values

$$\partial V_8 = 107[\partial V_{in} - \partial V'_{out} + \partial V_{eb2}(-i_1) - \partial V_{eb1}(i_1)] - 10\partial V_{eb7}(i_7) \qquad \text{Eq.(1)}$$

$$\partial V_9 = 107[\partial V_{in} - \partial V'_{out} + \partial V_{eb3}(i_2) - \partial V_{eb4}(-i_2)] + 10\partial V_{eb10}(i_{10}) \qquad \text{Eq.(2)}$$

For $\partial V_{in} > 0$, $\partial V_{eb1} > 0$, $\partial V_{eb2} < 0$, $\partial V_{eb7} > 0$, $\partial V'_{out} > 0$ and the effect of nonthermal V_{eb} variations is observed to decrease the gain at V_8. For $\partial V_{in} < 0$, $\partial V_{eb1} < 0$, $\partial V_{eb2} > 0$, $\partial V_{eb7} < 0$, $\partial V'_{out} \geq 0$ and again the effect of nonthermal V_{eb} variations is observed to decrease the gain at V_8. Similar results are observed for nonthermal V_{eb} variations on V_9.

This variation is constant as long as ∂V_{eb} is constant and this depends on the degree to which a linearizarion of the V_{eb} versus i_c curve is valid. Thus the circuit possesses V_{eb} variations which tend to reduce the gain of the amplifier below its theoretical value, G, which assumes $\partial V_{eb} = 0$, but as long as the used portion of the V_{eb} curves are linear the gain will be constant.

1.2.2.8 Effect of Thermal V_{eb} Variations

As V_{in} increases, P_2, P_3, and P_7 decrease and P_1, P_4, and P_{10} increase; thus T'_2, T'_3, and T'_7 decrease and T'_1, T'_4, and T'_{10} increase; thus V_{eb2}, V_{eb3}, and V_{eb7} increase and V_{eb1}, V_{eb4} and V_{eb10} decrease. Similarly, as V_{in} decreases, P_2, P_3, and P_7 increases and P_1, P_4, and P_{10} decrease; thus T'_2, T'_3 and T'_7 increase and T'_1, T'_4 and T'_{10} decrease; thus V_{eb2}, V_{eb3} and V_{eb7} decrease and V_{eb1}, V_{eb4}, and V_{eb10} increase. By Eqs. (1) and (2) thermal variations are observed to cancel since due to the linearization of the power dissipation curves: $\partial V_{eb7} = -\partial V_{eb10} = \partial V_{eb}$ stage 2, and $\partial V_{eb1} = \partial V_{eb4}$ $= -\partial V_{eb2} = -\partial V_{eb3} = \partial V_{eb}$ stage 1.

By choosing current levels such that $10\partial V_{eb}$ stage 1 $\sim \partial V_{eb}$ stage 2 $\partial V_8 \sim \partial V_9 \sim 0$ and the thermal drift is ~ 0. This topology with proper current levels and with the used portion of the power dissipation curves being linear produces a circuit which is only very slightly affected by temperature variations over the desired output range.

1.2.2.9 Pre-Output Stage Compensation

Obviously the linear approximations used are not exact and the variations at V_8 and V_9 will not be exactly linear or drift free. The constant-current pre-output stage will further compensate any deviations present at V_8 and V_9.

If $\partial(V_9 - V_8) > 0$, a larger pre-output current would be expected and V_{out} would be too large. This does happen but the error is drastically reduced.

For $\partial(V_9 - V_8) > 0$ and $V_9 - V_8 = V_{eb9} + V_{z1} + V_{R22} + V_{z2} + V_{eb8}$ the output current increase causes $\partial V_{eb9} > 0$, ∂V_{z1}, > 0, $\partial V_{z2} > 0$, $\partial V_{eb8} > 0$ which implies $\partial(V_9 - V_8) - (\partial V_{eb9} + \partial V_{z1} + \partial V_{z2} + \partial V_{eb8}) = \partial V_{R22}$.

For $\partial(V_9 - V_8) \sim .3v$ the experimentally measured values are $\partial V_{eb} \sim \partial V_z \sim 50$ mv. Thus $\partial V_{R22} \sim .1v$, since $\partial V_{11} \sim \frac{1}{2}\partial V_{R22}$, ∂V_{11} is only about 50 mv.

As V_9 increases, V_8 increases, thus P_9 decreases and P_8 increases or vice versa. It is easily seen that $\partial P_9 = -\partial P_8$ since emitter current is constant. Thus $\partial T_9 = -\partial T_8$ from which $\partial V_{eb9} = -\partial V_{eb8}$. These thermal changes thus tend to maintain $i_8 = i_9 =$ constant.

Thus, thermal and nonthermal variations in V_8 and V_9 are reduced by about 1/6 and the constant-current pre-output stage provides much of the compensation present in the circuit.

1.2.3 Practical Layout of Paramatrix

The Paramatrix System is distributed into two cabinets as shown in Fig. 11. The portion labelled A contains all the electronic parts and controls of the system; the portion labelled B contains only power supplies, relays, and the start-stop controls.

Referring to Fig. 11, A from top to bottom, the Paramatrix System consists of:

a) Input Simulator Controls

These controls consist of three sections. Section one contains 32 spring loaded switches and four center zero voltmeters. These enable the operator of the system to check the simulated four input curves.

Section two contains 128 potentiometers which set up the initial input curves.

Section three contains 128 micro-switches to turn off any of the 128 input potentiometers in case fewer than four curves are displayed.

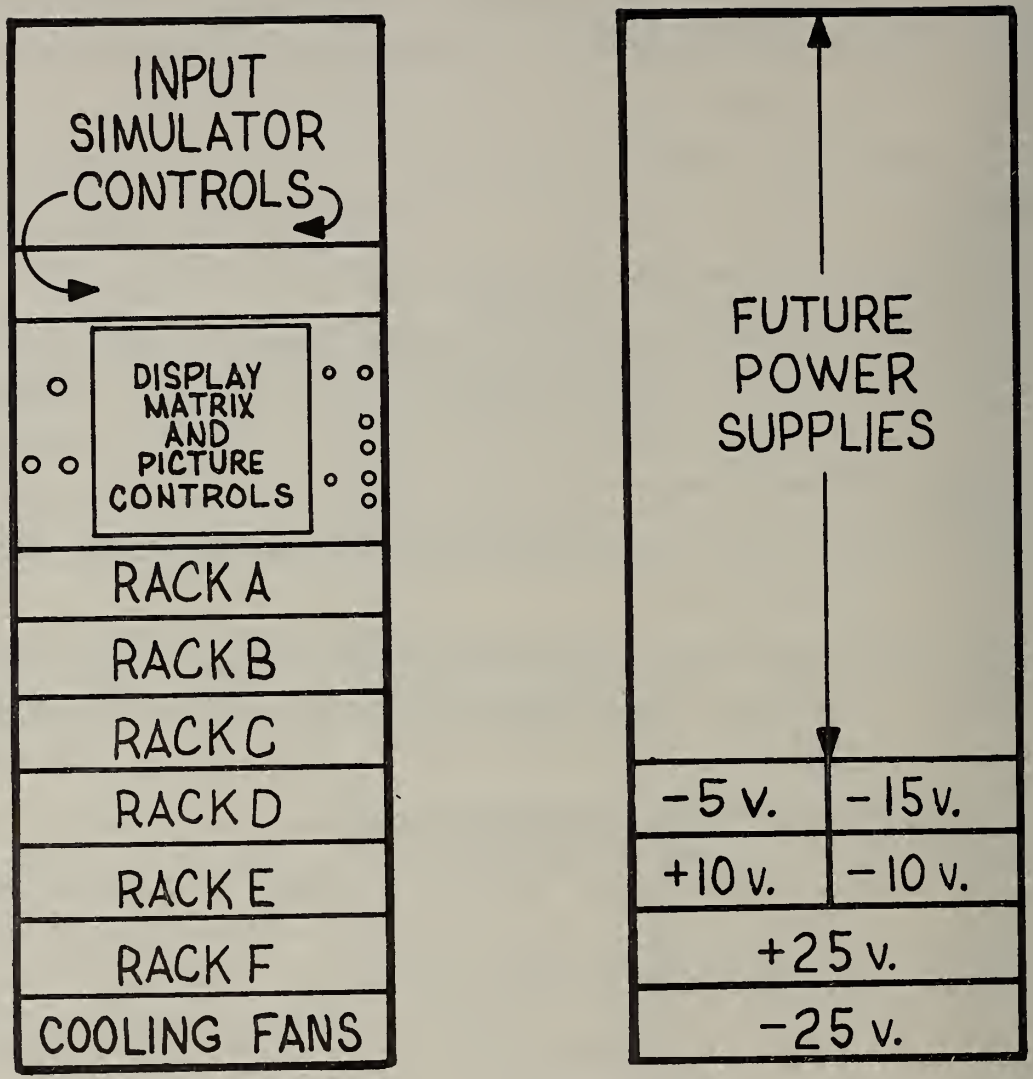
b) Display Matrix and Picture Controls

The Display Matrix consists of 32 rows of 32 bulbs. The picture controls consist of four sections. Section one is a sine-cosine potentiometer for picture rotation.

Section two contains two ordinary potentiometers to control X and Y picture translation.

Section three contains two potentiometers for controlling magnifications in the X and Y directions.

Section four contains three potentiometers for controlling the sensitivity of the thinner, interpolator and coincidence unit.



A

PARAMATRIX
SYSTEM
CABINET

B

POWER
SUPPLY
CABINET

Figure 11

c) Rack A, B and C consist of flipflops and flipflop drivers. Also rack C contains several switches to enable the operator of the system to connect an external clock or to operate manually.

d) Rack D contains the clock and logic for scanning the Paramatrix.

e) Rack E contains the transformer, thinner and coincidence units.

f) Rack F contains the Interpolator.

Also contained in the Paramatrix System cabinet are a set of relays which are the power supply controls to protect the circuits.

1.3 Electro-Optical Work

1.3.1 Low-Cost Keldysh Effect Modulator

The circuit for the optical differential amplifier was given in the preceding report. This circuit has now been modified to allow more versatility. The new circuit diagram is given in Fig. 12. The modifications allow better gain control and more convenient bias adjustment.

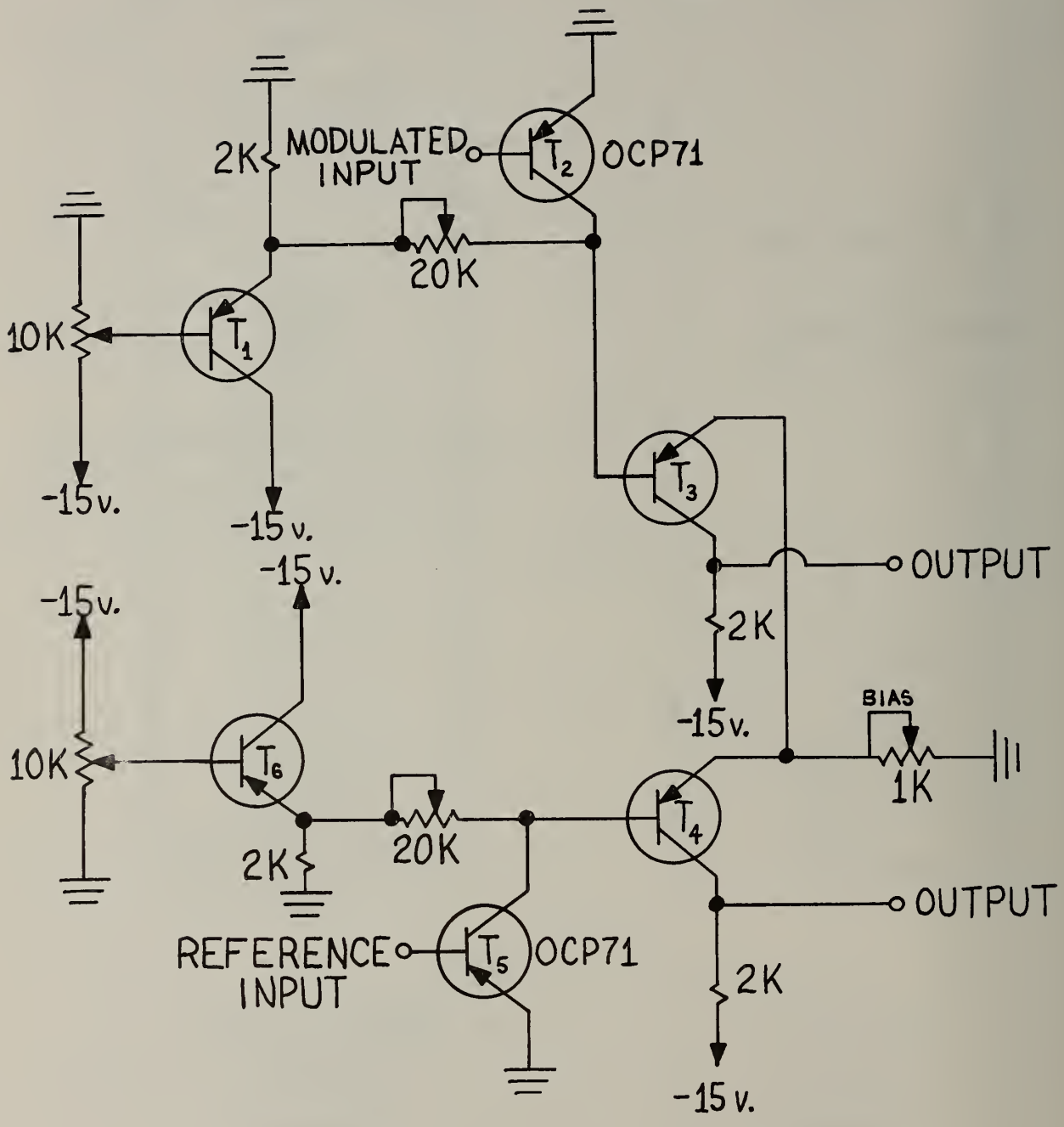


Figure 12. Optical Differential Amplifier

One might first think that an optical differential amplifier should consist of the two photo transistors placed in the standard differential circuit form. However, such a circuit allows very little flexibility. In the given circuit the photo transistors are used as adjustable inputs to the differential stage. This is very convenient: The Keldysh-effect modulator in the zero signal condition causes a great deal of attenuation in the modulated input beam. Hence the two input light beams are at quite different intensity levels, and adjustment of the related photo transistor bias is essential. Thus the optical differential amplifier is more correctly termed a photo-input differential amplifier.

Two interesting circuit refinements might prove desirable in the output stage. Replacement of the 1 K potentiometer with a current source transistor and the addition of a balance potentiometer are combined in Fig. 13. Consideration of the low cost objective for the circuit has prohibited use of the refinements in the present application.

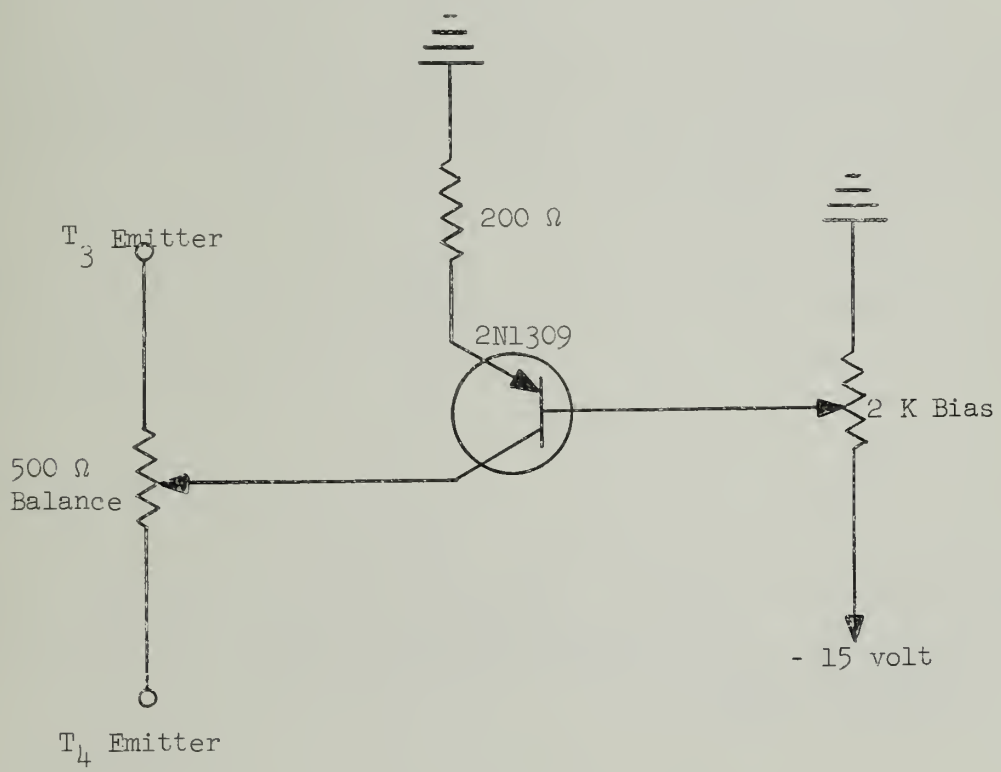


Figure 13. Possible Circuit Refinements

Data was taken for a number of photo transistors and calculations were made to obtain the collector current of the output stage as a function of the infrared light input. The source used was a gallium arsenide lamp which emits light at $0.9 \pm .02$ microne. The average change in collector current was then $1 \pm .1 \times 10^{-15}$ ma per photon/sec.

1.3.2 Preparation of p-n Junction Sample

In order to observe the modulation phenomenon, the junction has to be arranged such that an optical path perpendicular to the junction surface is possible. The arrangement is shown in Fig. 14.

The junction used is of the epitaxial type with a cadmium doped gallium arsenide substrate(p-type). The epitaxial layer is 20 microns thick and is selenium doped. The orientation of the wafer is [100]. The process to mount the junction on to the fixture is as following:

Because of the nature of our application, the orientation of the cut is not important, so that a high speed circular saw with a 5 to 10 mil blade is usable to cut the wafer. In order to reduce the vibration and stress exerted on the junction during cutting, the whole wafer is embedded in red wax on a substrate of plate glass or ceramic. The wax on the junction can be cleaned off with acetone solution.

The next step is to provide a spot on the epitaxial side to attach the lead. Since the surface of the epitaxial layer is too smooth to be "wetted" by n-type alloy, some gold diffused at the spot is helpful to provide an ohmic connection. To generate the ohmic contact the junction is covered by black wax except for the soldering spot. Then, a gold layer of a few microns is vacuum deposited on the spot. After the vacuum deposition, the black wax is cleaned off in trichloroethylene. The diffusion process is done in a hydrogen furnace with constant observation through a microscope. The temperature in the furnace is increased gradually until the color of the golden yellow spot changes into gray.

The material of the substrate which holds the junction (by soldering onto the p-side) has to be carefully chosen according to the temperature coefficients of the material and the gallium arsenide. A large difference in temperature coefficients will cause breaking of the soldering or the crystal. Cobalt has turned out to be an acceptable material. Before soldering the junction onto the cobalt plate, a layer of diffused gold on the cobalt surface is helpful. The cobalt surface is cleaned first by the mixture of 100 cc 50 per cent NaOH and 10 cc H_2O_2, and then by concentrated hydrochloric acid. After the surface is cleaned, gold is vacuum deposited onto it, (see last paragraph).

Soldering the junction onto the cobalt plate is done in two steps. First, the junction is immersed in the hydrogen furnace and a small grain of p-type alloy is attached to the p-side of the junction. The temperature is then increased gradually and the furnace turned off when the alloy forms a semi-sphere on the surface, as shown in Fig. 15. After this we put the junction on the cobalt plate in such a way that the alloy grain is on the inside. The temperature must be carefully controlled: overheating will cause the alloy to flow and this can possibly short the junction, as shown in Fig. 16.

To mount the lead on the n-side a process is used similar to that described except that we employ n-type alloy and a gold wire. The n-type alloy will easily spread on the gold spot and holds the gold lead. An alternate method is to use the silver paint (as used in repairing printed circuit cards). The gold lead is "glued" onto the spot by the paint. This is only good for temporary purposes, since the lead may get loose and the paint is soluble in acetone or trichloroethylene.

1.4 "Noise Computer"

1.4.1 Measurements of Frequency Distribution

Measurements of frequency distribution have been carried out for the random pulse generator (by random pulse it is meant the randomly spaced standardized pulse sequence as described in the last quarterly report).

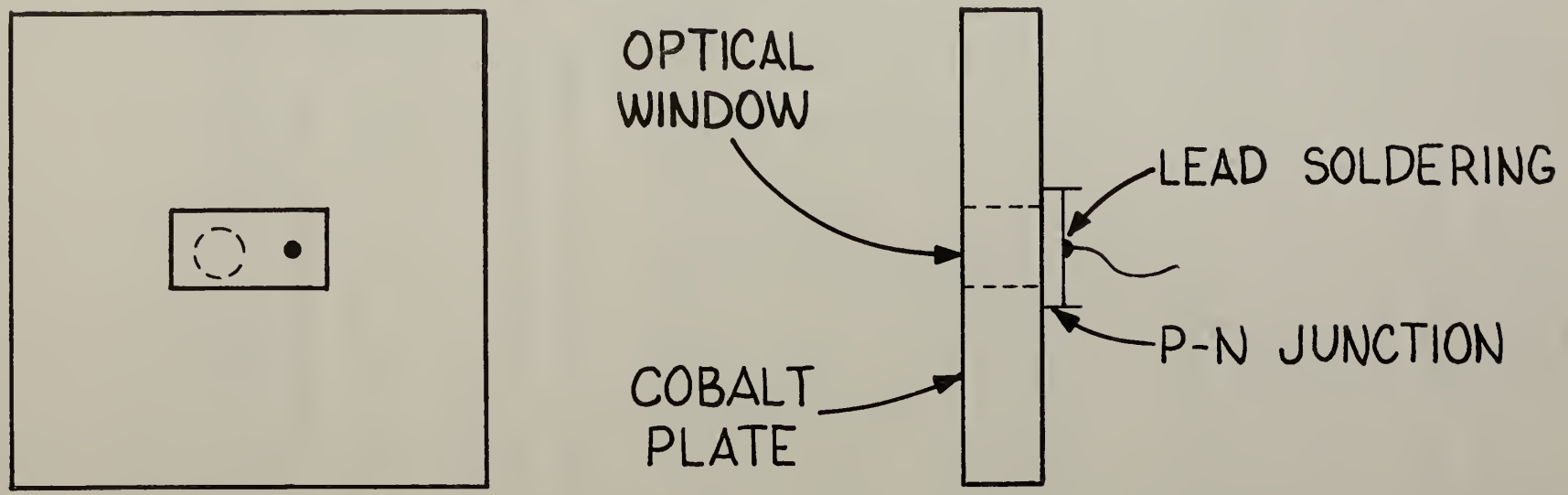


Figure 14. Arrangement of Optical Window

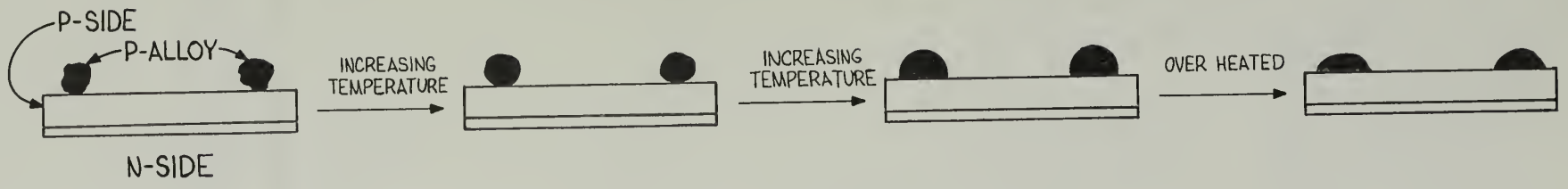


Figure 15. Alloying Operation of P-N Junction

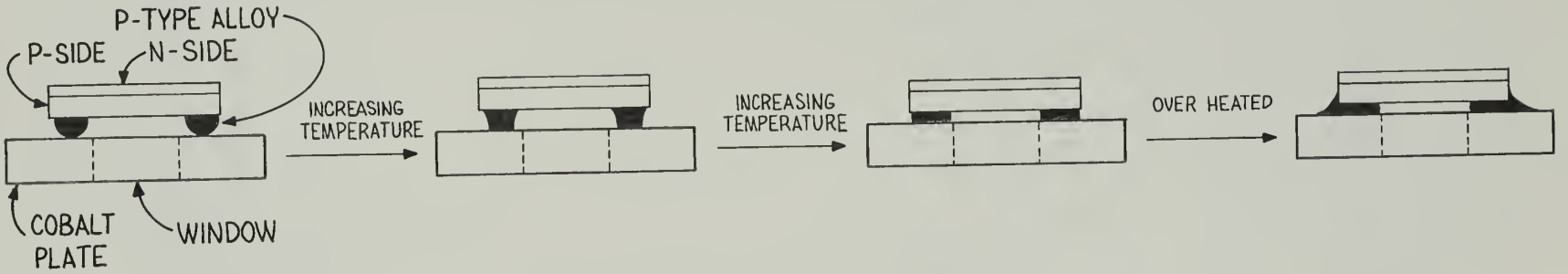


Figure 16. Attachment of Junction to Cobalt Plate

The block diagram of the experimental set-up is shown in Fig. 17.

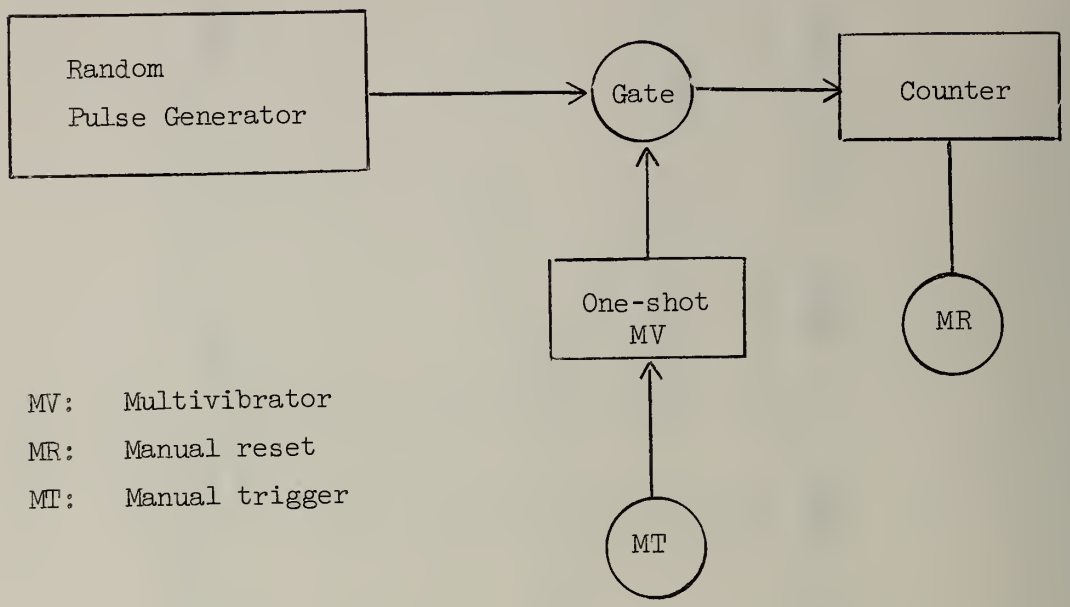


Figure 17. Experimental Set-up for Measurements of Frequency Distribution

It was observed that the frequency distribution of the random pulse varied as the applied voltage of the noise diode was varied. Fig. 18 (a) shows the frequency distribution for the case where the applied voltage of the noise diode is 4.8v and Fig. 19 (a) shows that for 6.0v. The time interval during which the number of pulses are counted is 0.5 msec for all measurements.

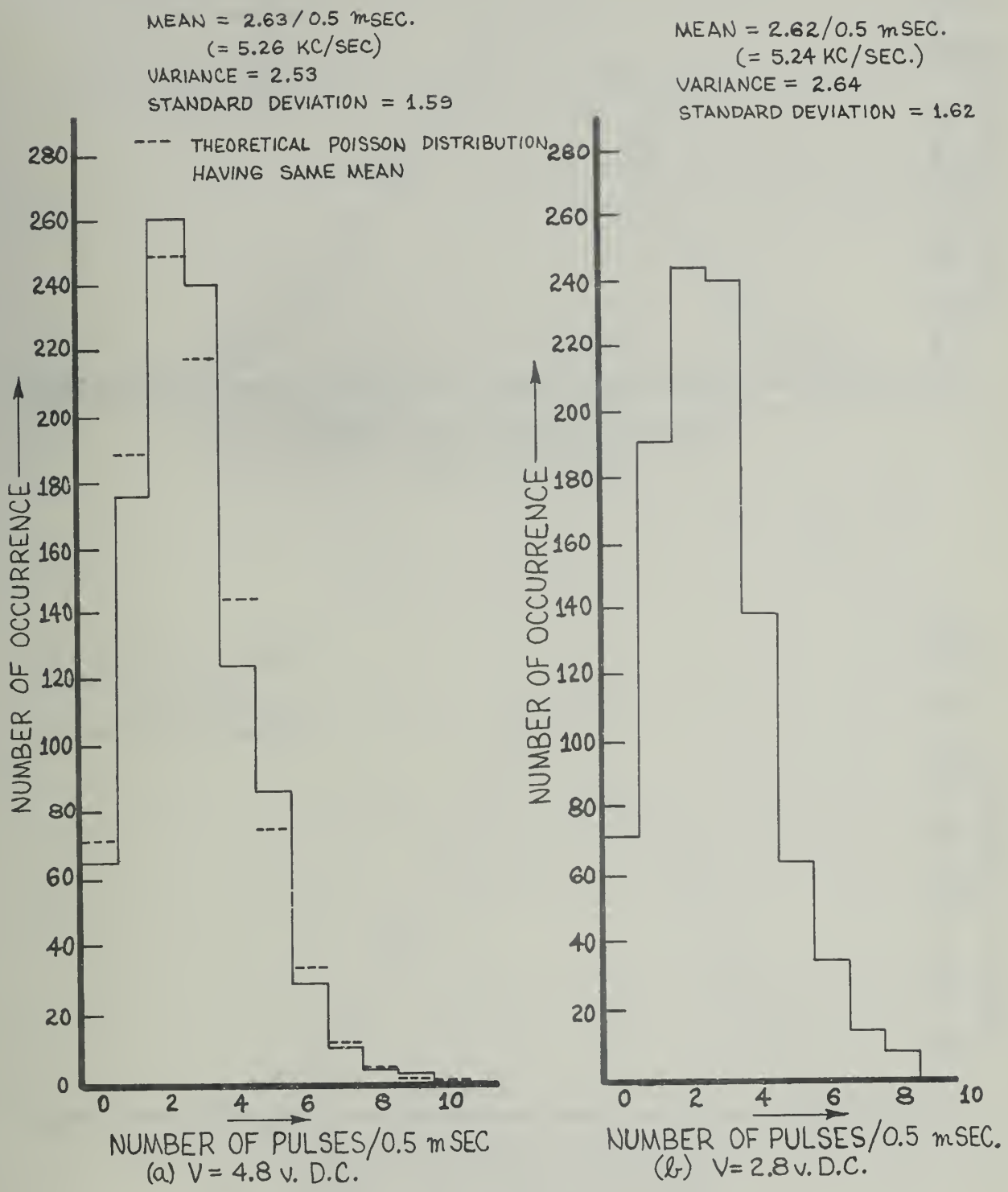
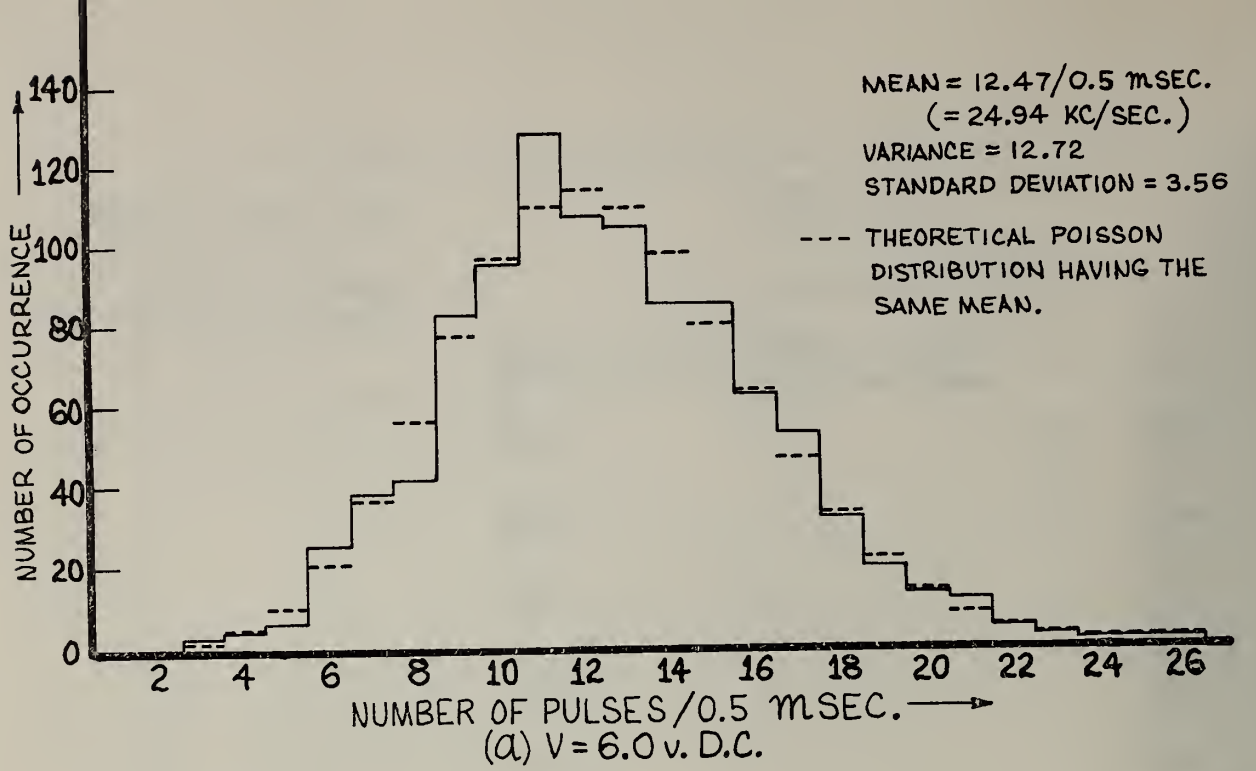

MEAN = 2.63 / 0.5 mSEC.
(= 5.26 KC/SEC)
VARIANCE = 2.53
STANDARD DEVIATION = 1.59
--- THEORETICAL POISSON DISTRIBUTION HAVING SAME MEAN
NUMBER OF OCCURRENCE
NUMBER OF PULSES/0.5 m SEC
(a) V = 4.8 v. D.C.
MEAN = 2.62/0.5 mSEC.
(= 5.24 KC/SEC.)
VARIANCE = 2.64
STANDARD DEVIATION = 1.62
NUMBER OF OCCURRENCE
NUMBER OF PULSES/0.5 mSEC.
(b) V = 2.8 v. D.C.

Figure 18. Frequency Distributions (1,000 Trials)



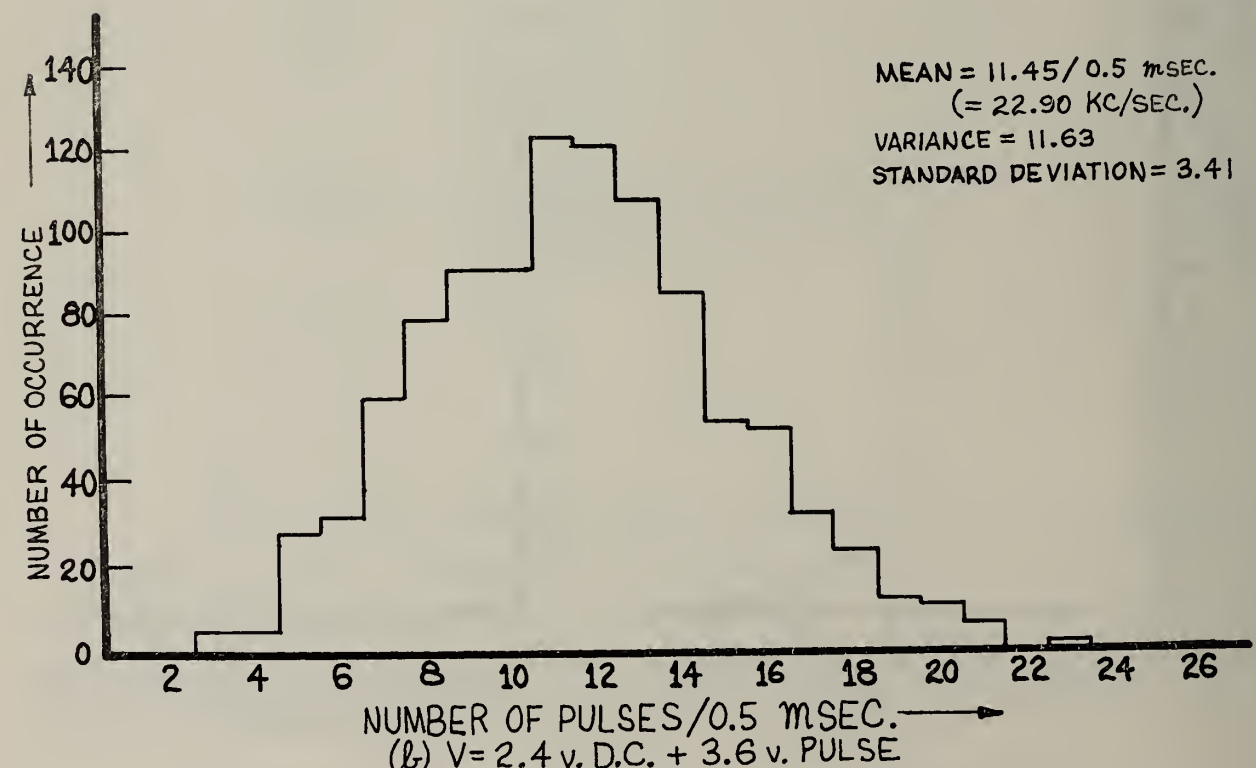


Figure 19. Frequency Distributions (1,000 Trials)

The results satisfy a Poisson distribution as expected.* The theoretical Poisson distributions having the same mean are plotted for comparison.

1.4.2 A Simple Method of Controlling the Average Frequency of the Random Pulse Generator

As mentioned in the previous section the frequency distribution of the random pulse generator varies as the applied voltage of the noise diode, V, varies.

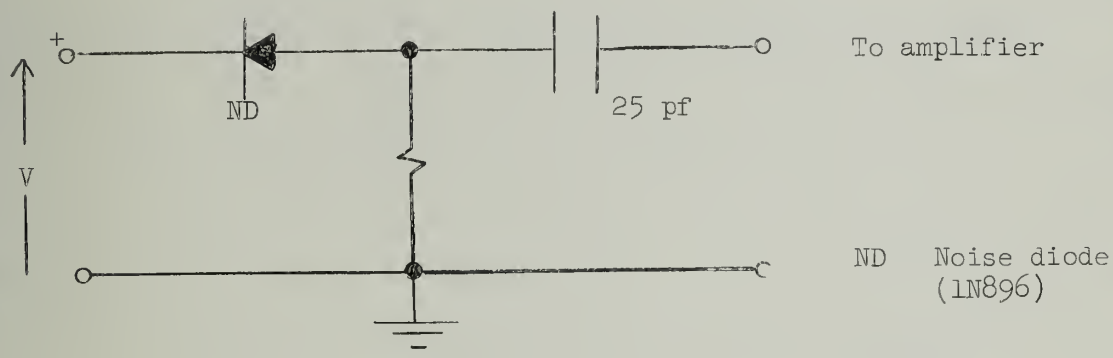


Figure 20. The Circuit for the Noise Diode

It seems that this behavior is essentially due to amplitude variations of the noise of the noise diode. These amplitude variations are then transformed into the frequency variations of the random pulse sequence at the triggering stage of the one-shot multivibrator.

Figs. 18 (a) and 19 (a) show the case where the applied voltage, V, is dc, (static characteristics). Figs 18 (b) and 19 (b) show the case where the applied voltage consists of 2.0 v dc and 0.5 msec rectangular pulse with its magnitude as specified in the figures (dynamic characteristics).

Comparison of the two pairs indicates that they essentially agree with each other. A slight difference in mean in each pair is well in the range of the standard deviation.

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* See "Remark", page 43 for explanation.

1.4.3 Test of Randomness by the Frequency Distribution

Some of the information on randomness of the pulse sequence can be obtained from the frequency distribution.

In Fig. 18, we see that there were events when no pulse occurred during 0.5 msec. This means that there was no periodical pulse whose frequency is higher than 1 pulse/0.5 msec (or 2 Kc/sec). If the length of the counting duration is extended, information on periodical pulses of lower frequency would be obtained.

By Fig. 19 we are assured that there is no periodical pulse whose frequency is higher than 8 Kc. In this case extension of the counting duration would not yield useful results. The mean is so high that the probability of having less than two pulses during 0.5 msec is exceedingly low. In fact the theoretical probability is about 3×10^{-4} for the case where the number of pulses per 0.5 msec is 2, i.e., if 10^4 trials were carried out we would observe the event three times on the average. Now consider the expression for the Poisson distribution

$$P(n;\tau) = \frac{(k\tau)^n}{n!} e^{-k\tau}$$

where

τ = counting duration

n = number of pulses during τ

k = average number of pulses during τ

We see that extension of τ makes the situation worse.

Although this test yields some useful information, it is not complete by itself. The cross correlation function method is still needed for a complete test in the lower frequency range where the above test fails to work.

Note that this test allows us to reach a negative conclusion (i.e., that there is no periodical pulse). However, it does not yield a clear positive indication (i.e., that there exists a periodical pulse) even in the presence of a periodicity.

Remark It is well known that the distribution of the number of zero-crossing during a given period τ for the function shown in Fig. 21 is the Poisson distribution if the occurrence of zero-crossing is random.

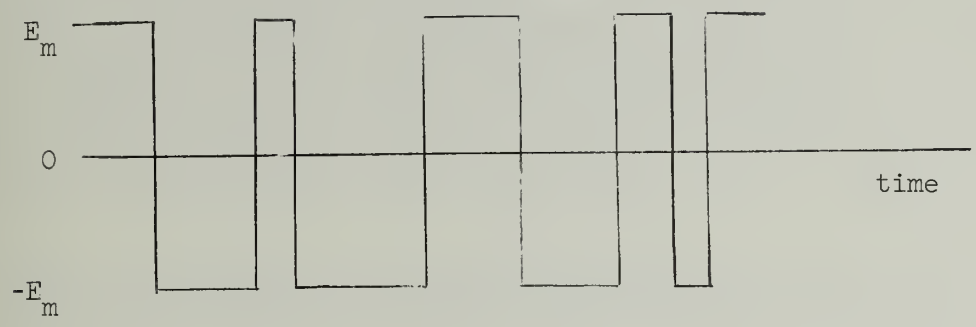

Figure 21. Rectangular Wave Alternating Between E_m and $-E_m$ at Random

The situation is exactly the same in counting random pulses during a given period.

2. THE ILLINOIS PATTERN RECOGNITION COMPUTER: ILLIAC III*

(This work is supported in part by Contract No. AT(11-1)-1018 of the Atomic Energy Commission.)

2.1 Introduction

The Illinois Pattern Recognition Computer (ILLIAC III) is being designed and constructed by the Department of Computer Science (1) with the immediate practical goal of providing a facility for the automatic scanning, recognition and analysis of nuclear interactions in bubble chamber negatives, and (2) as part of a long-range general study of the visual pattern recognition problem.

This summary serves principally as an index and guide to the main body of this technical report: consisting of a preprint of an IFIP 65 paper, a preliminary programming manual, a master's thesis, five additional laboratory reports, 11 file numbers and a further five file numbers concerning fabrication and testing submitted by title only. A bibliography of this material constitutes Appendix 1. The categories used there can be understood as follows: Section 1 contains Summary Articles; Section two through five describe major subdivisions of the ILLIAC III Computer System--the Main Frame, the I/O System, the Scanner/Monitor Center and the Power/Control System; Section six through eight list file memoranda on Systems Programming, Automatic Scanning of bubble chamber negatives, and theory of Visual Pattern Recognition; and finally Section nine lists Specification File numbers and Miscellaneous Articles. In addition at this time, August, 1965, there is a large body of information about the project which exists in preliminary manuscript form. A second bibliography, Appendix 2, lists six manuals, 15 reports and nine file numbers in this preliminary manuscript form, that is, in preparation.

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* The following 17 pages are taken from "Part I: Technical Progress Report-Summary," of File No. 681, Technical Progress Report for the Period September 1, 1964 through August 31, 1965. Appendices 1, 2, and 7 are contained in Sections 2.7, 2.8 and 2.9 respectively of this report. For the remaining appendices, refer to the original file number which may be obtained from the Department of Computer Science, University of Illinois, Urbana, Illinois, 61803.

The contract proposal for the 12-month period, October 1, 1964, through September 30, 1965, set up five areas for investigation. Briefly these were:

1. Logical Design and Hardware Construction of the Illinois Pattern Recognition Computer (ILLIAC III)
2. Documentation of the ILLIAC III Computer
3. System Programming for ILLIAC III
4. Automatic Scanning of Bubble and Spark Chamber Film
5. Investigation of Visual Pattern Recognition Theory.

Progress in each of these areas is outlined below

2.2 Logical Design and Hardware Construction of ILLIAC III

2.2.1 Circuit Design

Circuit design of the machine is now nearing completion. To date some 189 prototype printed circuit card types, exclusive of changes in etch pattern, have been examined (Appendices 12 and 13). Of these 135 printed circuit card types have been accepted for use in the final processors and terminals of ILLIAC III (Appendix 12). Counting variants introduced by the substitution of different components into a common etch pattern, the engineering and shop groups of ILLIAC III have developed 165 circuit configurations for active use in the final machine. Included in this list are circuits for power regulation, CRT analogue deflection systems, digital logic, core memories and semiconductor/printed circuit card testing.

2.2.2 Printed Circuit Card Fabrication

Appendix 11 summarizes the current status of all printed circuit cards of the system: on hand, or on order.

In summary, the central and very arduous task of the past year was the fabrication of 18,125 baby boards used in the stalactite assemblies of the Pattern Articulation Unit. (For production status summary see Appendix 7.)

In addition, the larger part of the circuit cards for the Transfer Memory (PAU) were fabricated entirely in house, and 1000 NAND/NOR (9) cards etched. Otherwise fabrication of other printed circuit cards was largely limited to prototype quantities.

In order to expedite the fabrication of the computer, orders for subcontracted fabrication of 3585 cards were let this contract year. Bids for an additional 6000 cards are currently in preparation.

2.2.3 Cabling and Wiring

Wiring of the Pattern Articulation Unit is nearing completion, and has been done entirely in house. Again in the interests of maintaining production schedule, virtually all wiring of bays and drawers of the digital (but not analog) circuitry has been subcontracted. There have been 240,000 taper pin wires ordered. Subcontracts for insertion of 80,000 wires have been let, and bids for an additional 160,000 wires are now being let for bid.

Signal and control coaxial cables in ILLIAC III uniformly handle a single 9-bit character: 10 cables for transmission, 10 cables for return and one spare (2 cables handle parity). Preliminary bids for these 200-odd cables were let during the contract year. Orders will now be placed on modified specifications.

And finally, largely precipitated by the problem of checkout of the Ampex Magnetic Tape System, the logical design and programming of a semi-automatic wire checkout unit was undertaken. This unit drives a paper tape punch to record all electrically common pins within a tray of a drawer or bay of the computer. The program to edit this data was programmed for the ILLIAC II Computer. Fabrication of the checkout unit is straight forward and will be undertaken in the fall.

2.2.4 Circuit Board Tests and Testers

Circuit boards destined for use in the ILLIAC III system are subjected to a series of tests prior to insertion in final equipment. From the viewpoint

of the testing program, there are two classes of circuit boards, (1) the Iterative Array boards and (2) common (non-IA) boards. Exceptionally rigorous testing of the IA boards is justified by their large quantity and high component density.

2.2.4.1 IA Board Test Program

Each of the 1156 cells of the IA (homogeneous portion) is contained on one "mother" board comprised of 15 "baby" boards. After assembly, the baby boards are tested according to the following program:

(a) Thermal Cycle

One thermal cycle is defined as + 140° C for 1.5 hours followed by + 25° C for 0.5 hours.
Each baby board is subjected to eleven cycles over a 22-hour time span.

(b) Isometric Test

Analog signals are applied to the inputs of the baby board such that the operating threshold of each nonlinear element produces a characteristic signature on the output waveforms. Since the threshold points are functions not only of the nonlinear elements, but also of the associated linear elements, the effect of any abnormal component can be distinguished.

(c) Dynamic Test

A sequence of high speed pulses are applied (see description of Dynamic Tester) so as to reveal any substantial stray capacitance or abnormal responses excited by rapidly rising pulses.
After the foregoing tests are performed, mother boards are assembled and the following final test is performed.

(d) Mini-PAU Test

The Mini-PAU Tester consists of a 16-cell model of the Iterative Array controlled by a 60-step sequence of micro-operations programmed in read-only Memory. The inputs of the mother board (1 cell) under test are duplicates of one of the 16 normal boards in the array. Thus, equivalence of the outputs of the normal board and of the board under test, after each step of the test sequence, provides significant assurance of correct operation in the context of a normal signal environment.

2.2.4.2 Common Boards

Non-IA boards are subjected only to Thermal Cycle testing followed by a test in the Dynamic Tester. Since most of the boards deliver a relatively simple function of their inputs, confirmation that all components and wiring are within reasonable tolerance limits requires only modest intricacy in testing.

2.2.4.3 Dynamic Semi-Automatic Circuit Board Tester

The tester which is described here is designed for evaluating circuit boards in production quantity as well as irregular one-board tests normally required for machine maintenance. The equipment is capable of dynamic (or static) tests of virtually all* presently existing boards associated with the ILLIAC III project.

The basic test performed on each circuit consists of applying all input states in time sequence and at circuit operating speed. If any component is substantially abnormal (in a practical sense), then the circuit output will deviate from the predicted range at some time. Output deviation can be detected by the emergence of the oscilloscope beam from behind an opaque mask, i.e., a mask which is opaque only where the correct output trace is expected to appear on the oscilloscope. The mask is the tolerance-broadened photographic negative of a correct output.

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* Power system boards and boards containing electro-mechanical relays are the only known exceptions.

The several circuit copies, appearing on each board, are sequentially selected by a solenoid-driven rotary switch which connects the proper inputs to the test circuit and the output to the scope for some tens of milliseconds. Accordingly, the time to test one board is fully adequate for production usage.

2.2.4.4 Program-Controlled Semiconductor and Printed Circuit Card Tester

A user manual for this automatic tester, on-line to ILLIAC II, was prepared by David Foster. The original design of S. Yamada is now being modified for a second generation instrument to be on-line to ILLIAC III.

2.3 Documentation of the ILLIAC III Computer

2.3.1 General

The system design of the Illinois Pattern Recognition Computer (ILLIAC III) is best documented in the Preliminary Programming Manual.[2] A summary description of the computer system will be found in the IFIP 65 Preprint.[1]

Logical design of the machine is not yet adequately documented and is still largely in preparation. Specifically all drawings are still considered working drawings and not final. A close parallel exists between the status of this logical design documentation and the status of printed circuit fabrication prior to this summer (1965).

Specific reports on system and logical design are noted by area in the two bibliographies (Appendices 1 and 2). An estimate of card requirements for each area of the machine will be found in Appendix 10.

2.3.2 Printed Circuit Documentation

Documentation standards for each production printed circuit card are rigidly adhered to. Typically a printed circuit is described in three sheets: for etch pattern, component configuration and circuit/logical description respectively. The current documentation status of every production printed circuit card configuration is summarized in Appendix 14. This work is proceeding rapidly, so that it is anticipated that this task will not delay construction of the computer.

A systematic notebook system for documentation of circuits and of the logic of the computer has been inaugurated. Specifically, four (11 x 17) notebooks are for circuits, and six notebooks for logic (Main Frame, I/O System, etc.).

2.3.3 Wiring Documentation

Several practical and theoretical tools have been prepared for the task of documenting, installing and checking out back panel wiring. Specifically, the documentation system is based upon the WEB programming language - with considerable care given to the input logic and packaging description and the output logic tracing table and wire listing formats.

In addition a wire minimization routine to assist in the layout of control logic has been written for ILLIAC II.

2.4 System Programming for ILLLIAC III

2.4.1 General

The ILLIAC III programming group has sought a framework for system programming which would be modular, summarizable in a few succinct tables, and universal; that is, the compilers for the machine engineering languages, the assembly language and the more conventional problem-oriented languages could be built along common lines. Fortunately Feldman, working with Perlis at Carnegie in 1964 appears to have formulated a partial solution. He suggested a compiler-compiler where both the snytax and the semantics describing the programming language are loaded as tables; the appropriate compiler for this language is then generated.

R. S. Northcote, working with the nucleus of the ILLIAC III Systems programming group, attempted to clarify this concept this past year.[13,14] An initial, if crude, compiler-compiler is now being coded for the IBM 7094; the first half of the code, called the Scanner, is operable. This program written by Albert J. Steiner, is approximately 6000 instructions.

Though the compiler-compiler technique may well mean initial inefficiency in run-time code, it is our contention that the unity, clarity, and experience brought to this area by this system's uniformity may well significantly shorten the time to get an operable systems package on the air. Furthermore this potential of the computer rests in the developing an extensive library of algorithms for visual pattern recognition and for facile communication between user and display station. A modern way of systematizing these algorithms is to define experimental task-oriented languages of ever-expanding capability. The compiler-compiler should fulfill this need.

Current attention now centers upon implementing four languages:

1. WEB: A language to Describe the Interconnection and Packaging of the Logical Units in a Digital Processor
2. IBAL: The ILLIAC III Basic Assembler Language
3. ALGOL-60, augmented by I/O ALGOL and
4. UNIVERSAL ALGOL, the basic systems programming language being developed for ILLIAC III.

Floyd productions for the first three languages now exist, with extensive documentation for ALGOL-60. These productions are machine independent, and so can be carried over directly to the ILLIAC III from the IBM 7094.

2.4.2 Continuing Tasks

As summarized above our program has been to base all programming language implementation upon the early completion of a compiler-compiler. Our experience with part of that work, the Scanner, suggests that this approach is both realistic and reasonable. Parallel approaches are underway at Carnegie (Perlis), Computer Associates (Cheatham) and Lincoln Laboratory (Roberts and Feldman). Our own approach takes its roots in the thesis of Feldman.

Development of the compiler-compiler can be categorized as follows:

1. (Short range) Appendage SCATRE (IBM 7094 Assembly Language) executes to the existing Scanner to get working WEB and IBAL languages.

2. (Intermediate range) Rewrite the Scanner, on the basis of new experience, in IBAL language--the ILLIAC III Assembly Language.

3. (Long range) Clarify the semantics of UNIVERSAL ALGOL, and in particular, implement a subset of this language largely equivalent to Feldman's Formal Semantic Language.

In essence, we are systematically evolving a genealogical tree of problem-oriented languages--from the most hardware-oriented description language to the superior-most executive system language. In ILLIAC III system programming, these languages are MICROSEQUENCE, WEB, IBAL, UNIVERSAL ALGOL and the ILLIAC III EXECUTIVE SYSTEM respectively.

2.5 Automatic Scanning of Bubble and Spark Chamber Film

2.5.1 Bubble Scan Program

The Bubble Scan I Program by K. Narasimhan gives a complete description of the first version of this program, as implemented in the IBM 7094-1401 System at the University of Illinois. Bubble Scan is concerned exclusively with the scanning of one view of a bubble chamber stereotriad. The input-output features, the data-structures and scanning procedure used are first described with specific reference to this IBM-7094 implementation. However some care has been taken to point out features intrinsic to the logical structure of Bubble Scan and to differentiate them from details which are merely relevant to this particular implemented version.

2.5.2 Film Transports

Of obvious importance for the production scanning of bubble chamber film is the design of the film transports. This past year the electro-mechanical design of two 46 mm transports for Alvarez bubble chamber film, and two 70 mm transports compatible for both Brookhaven and MURA film formats were completed and submitted to the shops. We benefited considerably from the experience of the High Energy Physics group at Illinois with the Scanning Measuring Projector. Further, a critical design decision was involved: shall the long film formats (Berkeley and Brookhaven) be imaged from one tube--hence requiring a supercritical

seven inch CRT system, or (as chosen for the initial film scanners of ILLIAC III) shall the film be mechanically positioned in two terminal positions, allowing scanning of ≈ 60 percent of the image from either position, with overlap. The selection of this later alternative allows us to retain the simple five inch CRT system. The pneumatically-operated film translation mechanism was designed to restrict nonreproducible transverse displacements to under two microns. This degree of control is essential if the sagitta of longitudinal beam tracks is to be reproducibly measured.

2.5.3 Film Scanners

The order code of the film scanners is presented in reference 6. A revised version of this report is in preparation, reflecting minor variations suggested with an eye to programming ease.

Each scanner is being built to operate in four modes: raster (TV-like scan with clock frequency sampling), coordinate, video and incremental. The first three modes can be used either for input or output: the fourth mode is largely for computer graphics display. Concurrent design of the scanners and the monitors has greatly enhanced the possibilities for convenient visual display. To assist initial systems programming development, a program simulator of the incremental mode using a CalComp incremental plotter has been written. Here the user enters ILLIAC II with card input paralleling directly the scanner order code language. Produced magnetic tape is then transferred to the CalComp unit to make a line drawing.

2.5.4 Monitors and Editing Language

A task of high importance is to develop a good fully-embedding macro-language for construction of image identification and interrogation algorithms. This investigation stemming from early studies of R. Narasimhan and J. Nievergelt was considerably stimulated by the macro-programming system of Philip Merryman developed for the CDC-160A at New York University Medical School. Mr. Merryman, now supported in part by this contract, is developing a similar prototype system at Illinois for the ILLIAC II. In particular, this system is remarkable for its simplicity, ease of console editing, and can

encompass quite sophisticated algorithms. Apart from the console editing language, an extended form of this language will be available to the user in IBAL (ILLIAC III Basic Assembler Language).

2.5.5 Teletype Remote Consoles

Finally, as a feature to assist remote users, in particular high energy physics users, provisions for the attachment of Module 33 ASR Teletype Consoles to ILLIAC III are being incorporated in the modified Monitor Communication Center design.

2.6 Investigation of Visual Pattern Recognition Theory

A comprehensive theory for the analysis and description of digitized pictures was developed this past year by S. Yamada.

The first phase of this general plan involves local recognition of visual patterns. The following subjects are investigated at the local recognition level:

(a) A General Labeling Routine
(b) Cleaning of Random Noise
(c) Shaping, including Burst Noise Correction, and
(d) Preliminary Extraction of Feature Objects.

One of the distinguishing aspects of this work is the emphasis placed upon the preprocessing necessary to extract feature objects and the optimization of choice of the feature object set. Conventional pattern recognition though blithely starts at the feature object set level and ignores, to our mind, the heart of the problem.

A second paper by S. Yamada discusses the syntactic description of pictures, presupposing that local image preprocessing has been completed.

B. H. McCormick, Principal Investigator
R. S. Northcote
S. R. Ray
K. C. Smith
S. Yamada

2.7 Bibliography of Manuals, Reports and File Numbers

Summary Articles

1. McCormick, Bruce H., Sylvian R. Ray, Kenneth C. Smith and Shigehura Yamada, "ILLIAC III: A Processor of Visual Information," Department of Computer Science, Report No. 183, June 10, 1965.

2. McCormick, Bruce H., (editor), "Preliminary Programming Manual for the ILLIAC III Computer," Department of Computer Science, Report No. 185, July 7, 1965.

Main Frame

3. Mayberry, Billy, "A Summary of ILLIAC III Stalactite Circuit Testing," Department of Computer Science, File No. 640, February 4, 1965.

4. Ray, S. R., "Details of Transfer Memory Input/Output Signals," Department of Computer Science, File No. 630, November 3, 1964.

5. Pelg, E., K. C. Smith, J. L. Snell, "PAU Iterative Array Stalactite Testing - 1-8 FF," Department of Computer Science, File No. 660-1, May 7, 1965.

Scanner/Monitor Center

6. Breeding, K. J., B. H. McCormick, and J. R. Witsken, "Order Code for the Film Scanners of ILLIAC III," Department of Computer Science, Report No. 176, March 22, 1965.

7. Yamada, Shigeharu, "Scanner/Monitor Center of ILLIAC III: Analogue Deflection Systems," Department of Computer Science Report (in preparation).

Power/Control System

8. Foster, David, "Operating Manual for the Program-Controlled Semiconductor and Printed-Circuit Board Test Console," Department of Computer Science, File No. 639, December 23, 1964

9. Greninger, Larson, "Formal Syntactic Techniques for the Optimization of Arithmetic Expression Calculations," Department of Computer Science, File No. 637, January 11, 1965.

10. Hazelhurst, J. H. and B. H. McCormick, "WEB: A Language to Describe the Interconnection and Packaging of the Logical Units in a Digital Processor: Part 1, Preparation of Input Data," Department of Computer Science, File No. 625, February 10, 1965.

11. Lieman, Daniel S., "Description of the WEB Wiring Table," Department of Computer Science, File No. 642, February 4, 1965.

12. McCormick, B. H., H. R. Johnson and J. R. Witsken , "Executive System of ILLIAC III: A Preliminary Description," Department of Computer Science, File No. 645, March 16, 1965.

13. McInnes, Allan W., "Floyd Productions for ALGOL-60," Department of Computer Science, Report No. 179, May 28, 1965.

14. Northcote, R. S., and A. J. Steiner, "A Syntax Loader and Subscanner for a Compiler-Compiler," Department of Computer Science, File No. 633, December 1, 1964.

15. Witsken, John R., "A Preliminary Study of the Executive Routine and Console File Control of ILLIAC III," Department of Computer Science, File No. 627, August 19, 1964. (Obsolete, see item 12)

Automatic Scanning

16. Narasimhan, R., "The Bubble Scan I Program," Department of Computer Science, Report No. 167, August 18, 1964.

Pattern Recognition

17. Breeding, K. J., "Grammar for a Pattern Description Language," Department of Computer Science, Report No. 177, May 27, 1965.

18. Ray, S. R., "Assorted Topics in Automatic Document Retrieval," Department of Computer Science, File No. 631, October 19, 1964.

19. Yamada, Shigeharu, and S. P. Fornango, "Experimental Results for Local Filtering of Digitized Pictures," Department of Computer Science, Report No. 184, June 15, 1965.

Specifications and Miscellaneous

20. Dutton, Ted F., "Etched Printed-Circuit Fabrication Process Performed by the Chemical Preparation Department," Department of Computer Science, File No. 647, April 1, 1965.

21. Foster, David, "Specifications for Internal Drawer Wiring of ILLIAC III Printed Circuit Card Drawers," Department of Computer Science, File No. 550-54, April 9, 1965.

22. Mullins, W. E., "1018 Card Tester Programs," Department of Computer Science, File No. 665, June 21, 1965.

23. Prendergast, L. A., and K. C. Smith, "ILLIAC III Circuit Book Notes," Department of Computer Science, File No. 650, July 6, 1965.

24. Sekerke, Jeffrey, "Quality Test of High-Current Contactors," Department of Computer Science, File No. 634, November 25, 1964.

2.8 Bibliography of Manuals, Reports and File Numbers in Preparation

Packaging and Interconnection Wiring

1. Lieman, Daniel S., "A Wire Length Minimization Program," Department of Computer Science File Number.

2. Ong, Avelino, "Design and Use of the Automatic Wire Checkout Unit," Department of Computer Science Report.

3. Schwebel, John C., "Program for the Automatic Checkout of Wiring," Department of Computer Science File Number.

4. Witsken, John R. and William D. Bond, "Floyd Productions for WEB," Department of Computer Science File Number.

Main Frame

5. McCormick, Bruce H. and Shunichi Toida, "An Algorithm for the List Structure Representation of a Figure," Department of Computer Science Report.

6. McCormick, Bruce H. and Shunichi Toida, "Pattern Articulation Unit of ILLIAC III: System and Logical Design for the Border Transfer Instructions," Department of Computer Science Report.

7. Lum, Vincent, and Bruce H. McCormick, "Pattern Articulation Unit of ILLIAC III: System and Logical Design for the Planar Transfer and Vector Transfer Instructions," Department of Computer Science Report.

8. McCormick, Bruce H. and William J. Watson, "Pattern Articulation Unit of ILLIAC III: System Design for the Homogeneous Instructions," Department of Computer Science Report.

9. McCormick, Bruce H. and William J. Watson, "Pattern Articulation Unit of ILLIAC III: Logical Design for the Homogeneous Instructions," Department of Computer Science Report.

10. Magnuski, Henry S., "A Report on the Operational Testing of ILLIAC III Fast Register Circuitry in the Flow Gating Memory of ILLIAC II," (Undergraduate Honors Project), Department of Computer Science File Number.

11. Kamae, T. and Shigeharu Yamada, "Performance Characteristics of a Borrow Save Subtractor for ILLIAC III," Department of Computer Science File Number.

12. Yamada, Shigeharu, "A Theory of Wiring Noise," Department of Computer Science File Number.

13. Pelg, E., K. C. Smith and J. L. Snell, "PAU Iterative Array Stalactite Testing 0-7 FF," Department of Computer Science File Number.

I/O System

14. McCormick, Bruce H. and J. V. Wenta (editors), "Ampex Magnetic Tape System for ILLIAC III: General Description," Department of Computer Science Manual.

15. McCormick, Bruce H. and J. V. Wenta (editors), "Ampex Magnetic Tape System for ILLIAC III: Master Controller," Department of Computer Science Manual.

16. McCormick, Bruce H. and J. V. Wenta (editors), "Ampex Magnetic Tape System for ILLIAC III: Data Controllers," Department of Computer Science Manual.

17. Wenta, Joseph V., (editor), "Ampex Magnetic Tape System for ILLIAC III: Tape Stations," Department of Computer Science Manual.

18. Wenta, Joseph V., (editor), "Ampex Magnetic Tape System for ILLIAC III: Transport Mechanism," Department of Computer Science Manual.

19. McCormick, Bruce H. and J. V. Wenta (editors), "Ampex Magnetic Tape System for ILLIAC III: Exerciser," Department of Computer Science Manual.

Scanner/Monitor Center

20. Breeding, Kenneth J. and Bruce H. McCormick, "Scanner/Monitor Center of ILLIAC III: Logical Design of the Scanner File Control," Department of Computer Science Report.

21. McCormick, Bruce H. and Avelino Ong, "Scanner/Monitor Center of ILLIAC III: Logical Design of the Monitor File Control," Department of Computer Science Report.

22. Ong, Avelino and Bruce H. McCormick, "Scanner/Monitor Center of ILLIAC III: Monitor Order Code," Department of Computer Science Report.

Systems Programming

23. Johnson, H. Randall, "Bibliography: Computer Graphics," Department of Computer Science File Number.

24. Johnson, H. Randall, "Bibliography: List Structures," Department of Computer Science File Number.

25. Johnson, H. Randall, "Bibliography: Pattern Recognition," Department of Computer Science File Number.

26. McCormick, Bruce H. and Albert J. Steiner, "Generalized ALGOL: A Preliminary Proposal," Department of Computer Science Report.

27. McCormick, Bruce H. and John A. Wilber, "A Computer Oriented Language for Computation," Department of Computer Science Report.

28. Steiner, Albert J., "Description of the Compiler-Compiler Subscanner," Department of Computer Science File Number.

29. Steiner, Albert J., "Introductory Description of the Compiler-Compiler," Department of Computer Science Report.

Pattern Recognition

30. Yamada, Shigeharu, "Machine Recognition of Pictures I: Local Filtering," Department of Computer Science Report.

31. Yamada, Shigeharu, "Machine Recognition of Pictures II: Global Recognition by Abstractive Expressions," Department of Computer Science Report.

2.9 Production Status: Stalactite Assembly*

Chip Type	Total Need	Layout	Etch	Drill	Assemble	Solder	Static Test	Repair	Tab Shear	Print Coat	Fabrication Complete	Dynamic Test	Mother Bd. Assembled
0-7 FF	9600						2900				6700		
M - FF	1200							300	900				
Input Gate	1125								1125				
Border Input Gate	200		200										
In/Out Comp	2400						950		1450				
Up/Down	1200						1200						
0-1 Driver	1200						1200						
True/ False	1200				650		550						
Summary	18,125		200		650		6800	300	3475		6700		

* This appears as Appendix 7 in File No. 681.

3. ILLIAC II RESEARCH AND SERVICE, USE, AND PROGRAM DEVELOPMENT

(This work is supported in part by Contracts No. AT(11-1)-415 and No. AT(11-1)-1469 of the Atomic Energy Commission and in part by the University of Illinois.)

3.1 ILLIAC II Program Development

3.1.1 Progress

This quarter concern has been centered on correcting, adding, refining, and tying up loose ends of the existing system programs in order that plans for the new time-sharing system may proceed with clear conscience.

An experimental and limited time-sharing routine (which handles batch processing as before but also permits use of SØC from the consoles) is almost ready for use. The ideas generated for handling console-type devices and the experience gained from their use will aid in development of future systems.

Pass 1 and Pass 4 of NICAP have been modified in order to provide more and better source deck information to the programmer. Progress has been made in further planning and code-checking of the Macro Prepass. FØRTRAN work has centered on the implementation of Hollerith strings to call parameter lists and arithmetic assignment statements as well as additional error diagnostics and consideration of line numbering.

A CalComp Digital Incremental Plotter was received in June. There has been much interest expressed in its use and programs are being written to handle this demand. The modifications necessary for SYSIØ to handle plotter output have been completed. A converter program which picks plotter data off the output tape and packs it onto a separate tape later hung on the plotter for off-line operation is working.

Since the format of the entire system tape has been changed in the past few months, it was necessary to write a new system tape update program which included a binary card linking, relocating loader. Some additions are being planned for the special register 34 dump program.

A file updating system has been written and is being used to modify files held on a user's file tape, to allow them to be processed by the batch processor, and to return them to the user's tape. This program was written as an experiment in data manipulative schemes and to enable the user to change small records on his tape without going through a new code-check.

At present the normal mode of system operation is off-line, under monitor control with interrupts allowed. Exceeding the limits on user cards out, pages out, execution and run-time cause immediate program termination. The IBM Selectric Typewriter is an integral part of off-line operation. The I D and name of each user and a message which tells if the program executed or not is typed to the machine operator. The real time decimal clock is now used to record the time and date of program execution on the printed output. In addition, the real time is typed to the operator each time a bootstrap is performed; the main purpose of this is to maintain records of how and when the machine is in use.

All system dumps are now controlled by the $DUMP Card. Thus except for core parity errors, a SYSERR or MONITOR ERROR DUMP will be given only if the $DUMP card is part of the user's input deck. The present system uses a 4-block monitor and requires both tape channel 4 and 5. Several SR-34 options have been added including a "restart," "start next," and write double EØF on output tape." In addition, the new system program SYSETC has had its function extended. Thus the system in general has been made more flexible and more independent.

Further work on SYSAUX has been in the area of code-checking the disk input-output routine. A memo with specifications for a CALL sequence, explanation of anticipated method of disk usage, and description of allowable operation codes has been issued. Disk hardware continue to be modified as software needs and hardware deficiencies are recognized.

The Library has seen further additions and other subroutines are in the development stage. Of major import were corrections to the Print, Punch, Read routine and the additions of a recoverable Dump routine and the dynamic program analysis routine TRACE. The CalComp plotter has opened a new area of Library program development.

A new system of passing along information to programmers in the Department of Computer Science has been implemented. These Program Memoranda discuss plans and ideas for further system development and provide rapid dissemination of current topics.

One of the major developments in this quarter was the decision to purchase a PDP-7 Satellite Computer which will receive lines of information from remote console stations, do some minimal processing, and then transmit a "buffer's-worth" of data to the ILLIAC II. This will greatly relieve the load on the ILLIAC and permit it to do more efficient processing. Study of the hardware and order code of the PDP-7 as well as programming of the simulator is under way.

3.1.2 System Program Development

The ILLIAC II operating system was expanded and modified. Zero execution time will not cause immediate termination but will allow the user to compile and assemble programs. Zero total run time is illegal. The time of day and date that each job is started appears on the printed output. The typewriter is giving more and better messages to the computer operator in the batch processing of ILLIAC II programs. A special SR34 option to allow single job runs has been added and other features previously planned are now in working order. Before termination of the user, the system now waits for completion of all I/O transfers on both tape channels.

SYSIO seems to be in a constant state of change. New options have been provided both for the user and the system programs. In connection with changes in SYSIØ, a new input-output tape format is in use and internal control words have been added. The "look-at" card option transfers the card image to the user's buffers but does not reset the necessary counters in SYSIØ itself; thus subsequent "look-ats" or the next read will transfer the same image. Being that the standard mode of operation is off-line, only compatible modifications necessary for continued use have been made to the on-line SYSIØ.

The entry into SYSIØ for the CalComp plotter is of the standard type. The address of the first location of a 20-word buffer is given. Here the plotter characters are packed in bits 9-12 of each quarter word, i.e., four per ILLIAC II word. These records, as with printed and card output records, are put onto

the output tape and recognized by the 1401. The operator is notified that the output tape contains plotter information. The operator then processes the output tape via a converter program to produce a plotter tape with long records (or few record gaps) and the special initializing and terminal words. This conversion is now being done on the ILLIAC II but will be expanded and relegated to the 1401. Features such as adding checks to protect one user's plots from other users and from himself, spacing plotter output; and easier means of identifying a given user's output (such as name and run number) are being considered and coded.

SYSETC is now a working system subroutine. It's options include setting up of a given system action in case of accumulator overflow and a read of the interval timer. If called ahead of time, end of tape and excessive drum and tape errors need not cause termination of execution.

Since drum bootstrap, load monitor program, load systems program, load procedure program, and update have all had major revisions or are completely new, a description of the run-time sequence of system routines and explanation of key control words and tables has been written up. All these programs are now in everyday use. There has been further changes in the file numbering and organization of the system tape. Both a 4 block on-line and 4 block off-line monitor are now on the system tape and reside in separate files. The decision as to which is to be used is made at bootstrap time via the special register on the operator's control panel, SYSERR, MONITOR ERROR, and the LOAD PROCEDURE program are now resident on the drum during batch processing; this provides a faster recovery from errors and more efficient sequencing of programs on the system tape. Thus both the drum map at run-time and the system tapes map have been modified from previously operating systems.

Because the use of the new system tape update program is far less than that of other programs on the system tape, it now appears at the end of the tape. The operation of the new update program is identical to normal batch processing except for the setting of SR34 at bootstrap. The input deck is made up in the normal form, i.e., EØF card, one update job deck, EØF card,

one job deck, etc. Each deck consists of a standard batch ID card followed by the update control cards reads and processed one by one at run-time. To use this update program, the system tape must have the following file format: each file consists of

a. an EØF
b. a 256-word record containing the number of the file and a BCD label
c. N records of information.

The new file update program uses the IBM Selectric console typewriter for input and output communication thus freeing ILLIAC II from the 1401. The existing version is restricted to internal DCS use because it only operates in the interrupt disallowed mode. All date is stored in files that have user assigned unique names and consist of an ordered set of logical records. Each record is either a BCD or binary card image, or a printed line image. With this program, it is possible to move around files on tape in the off-line mode; i.e., files on the input tape may be placed on other tapes, copied onto an output tape for subsequent printing or punching, merged, and/or processed via the batch routine. Furthermore, N typewriter lines may be inserted, printed, or deleted. Thus much data manipulation may be handled without going through changing of card decks and handling of cards.

The Disk SYSAUX routine requires many parameters in order to assure flexibility in formatting the disk, allow all possible operation codes to be handled through the routine, and permit recovery from errors. The minimum information which must be supplied is:

a. operation code
b. input or output
c. core address
d. error exits or variety of conditions
e. disk file frame, module
f. cylinder and surface--track number
g. record class
h. record address
i. number of multiple blocks needed.

An effort has been made to keep the arrangement of this information in the subroutine's parameter list as similar to that of the tape and drum as possible. Allowing the programmer to determine the cylinder and surface and having the program convert these two numbers to the equivalent track number offers the easiest method of addressing the disk file and permits program efficiency by giving maximum amount of information concerning the placement of the data. In agreement with the old SYSAUX philosophy, a transfer will not have been completed when control is returned to the programmer. However, any previous operation for the particular module and file frame called is guaranteed to have been completed successfully. Presently, minor code modification and checking continues. A package which handles disk errors still needs to be programmed and in all probability will reside on the drum at run time.

An I/O package for use with the ILLIAC II, IBM 1050(s), IBM Selectric Typewriter, and Teletype was developed to be used with the initial time-sharing package. Once the I/O routine was established, the planning and coding was done for the processor which handles time-sharing of Batch and SØC. Future expansion was kept in mind. Code-checking is taking place and a preliminary version of the time-sharing system works with a number of minor constraints. Refinement and elimination of nuisance value errors is being done.

The following is a list of publications distributed this quarter concerning the above programs:

Title	Source	Date
New Operating System Changes	Notice	April 27, 1965
Changes to SYSIØ	Prog. Memo. #7	April 26, 1965
System Changes	Memorandum	June 23, 1965
Plotting Operation for System Plot Tapes	Memorandum	June 25, 1965
Instructions in Using the Converter Program	Memorandum	June 24, 1965
SYSETC	Memorandum	June 1, 1965
Run-Time Sequence of System Routines	Memorandum	June 29, 1965
System Tape Update Proposal	Memorandum	May 12, 1965
System Tape Update	Memorandum	June 25, 1965
Time-Share Use of TS and Batch	Memorandum	May 19, 1965
A Provisional File Updating System	Prog. Memo. #1	April 2, 1965
File Updating System	Prog. Memo. #1 Change 1	May 12, 1965
Disk File Use Through SYSAUX	Prog. Memo. #6	April 22, 1965

3.1.3 FØRTRAN, the ILLIAC II Compiler

Several errors in the FØRTRAN compiler have been corrected and are a awaiting an update of the present system tape. Among these are:

a. Insertion of checks and error messages for constants in the source deck of FØRTRAN programs which cause overflow or underflow during conversion or during storage into a memory word.

b. Correction of the conversion constant which causes errors in the translation of constants whose exponent, E, and number of digits in the mantissa to the right of the decimal point, N, satisfy the inequality $|E + N| \geq 16$.

c. Insertion of a check and error message in an attempted call of a dimensioned variable.

d. Implementation of Hollerith strings of one word or up to eight characters in call parameter lists and arithmetic assignment statements.

Consideration has been given to the use of line numbers of up to six BCD characters rather than the sequential statement numbers presently assigned each statement of FØRTRAN by the compiler for error message reference.

Relevant publications this quarter:

Title	Source	Date
Remote Console Line Numbers for FØRTRAN	Prog. Memo. #13	May 19, 1965

A section on FØRTRAN II for the ILLIAC II User's Manual has been completed.

3.1.4 NICAP, the ILLIAC II Assembler, and the NICAP MACRO PREPASS

The diagnostic listing of names used in an assembly given by NICAP has been extensively modified. The regular name table is now alphabetized and a second reference table has been added. This reference table is a great aid in checking for errors in a program; it lists the names in alphabetical order together with the numbers of all cards where each name was used. If the name was not used, the message NØT USED is printed. The number of the card where a name was defined is also given, if applicable; otherwise the appropriate message is printed--UNDEFN, if the name was simply not defined, CALLED if called as an external subroutine, or DOUBLE if doubly defined. A label may be used more than 1,400 times before forcing the reference table routine to stop searching for more uses.

Hopefully, in the near future, the entire name and reference table listings will be made conditional upon a $PRINT OBJECT control card, permitting faster assemblies for those not desiring a listing with all its associated diagnostics. Error messages will be given regardless of the $ control cards present.

The MACRO PREPASS has been further programmed and checked out during the past quarter. Major additions were inclusion of variable length parameters and reserved symbol construction. A complete vocabulary was designed and implementation begun. The proposed set of mnemonics is

a. SKIP (+) D--all cards following this order will be ignored up to the card immediately following the card with "D" is reached.

b. SET A,(±) B--B is placed in A (with store order dependent upon sign given before B).

c. DE OP,A,(±) C, (+) D-- is a decision function which skips as in SKIP dependent upon a condition generated by the comparison of the A and C parameters.

As usual certain error conditions will cause the prepass to terminate. Among these errors are

a. more than 255 MACRO'S defined

b. a single BCD name has more than six characters

c. more than 7^4 reserved symbols are needed.

All MACRO mnemonics will appear at assembly time as "comment" cards with the appropriate substitutions of parameters, i.e., they will appear in listings, but no code will be generated for them by the passes of NICAP. The MACRO mnemonics include those operations defined above as well as any CALL's.

3.1.5 LIBRARY, ILLIAC II

Additions are constantly being made to the ILLIAC II subroutine library. The graphing routine for the off-line printer is now plotting points but the intricacies of the program are still being code-checked. The subroutine which numerically integrates systems of simultaneous linear first order ordinary differential equations is now being code-checked. A sixth order Adams-Bashforth predictor-corrector method is being used. The method presently being tested for finding starting values is Runge-Kutta with a step size equal to one-half the minimum step size given by the user.

Research is being done in preparation for writing a subroutine to find eigenvalues and eigenvectors of matrices. At present, it seems that Givens' method, although more difficult to program than the Jacobi serial method or the Jacobi threshold method, will in the long run be best for real symmetric matrices because the errors can be controlled. Subroutines now existing in the SHARE library are being investigated as are algorithms for the QR method which appears in the April, 1965, issue of the "Communications of the Association for Computing Machinery."

The following subroutines which were previously on the Library tape have had write-ups distributed in the past quarter:

TIME--reads the interval timer
(Memorandum, May 12, 1965)

SIN2-CØS2--calculate Sin and Cos by Chebyshev Polynomials
(Memorandum, May 6, 1965)

SLQ2--simultaneous linear equations solver
(Memorandum, May 13, 1965

New subroutines which have been added to the Library Tape are:

PLØT or CCP1PL--a CalComp subroutine which among other things moves the pen to a given position
(Memorandum, June 24, 1965)

SYMBØL or CCP2SY--a CalComp subroutine which causes the plotter to write N symbols in a given specified form
(Memorandum, June 24, 1965)

FPT1A--controls the action on accumulator overflow in FØRTRAN
(Memorandum, May 26, 1965)

CDUMP, PDUMP--a nonterminating printing dump routine which may be called in NICAP to give a partial or complete core dump and fast register dump in a number of possible formats
(Memorandum, May 6, 1965)

CLØCK--a NICAP service routine which reads the Real Time Decimal Clock.
(Library Program Write-up, May 24, 1965)

Two other most important subroutines have been added to the Library Tape but their write-ups have not yet been published--TRACE and TRACEB. They are both general purpose diagnostic routines which print the results of the execution of any order or block of orders (within certain specified limits) of the calling program. This provides, in some ways, better information for the debugging of a program than is available from an on-line code check. The difference between TRACE and TRACEB is that the former may not be used if the user calls the PRINT routine with a "partial call." Thus TRACEB is identical to TRACE except that it contains its own print routine and as a result is about 50 per cent larger. A third type of trace routine will never be put on the Library Tape but will be available as a source card deck. This type will trace protected orders; otherwise, its action is identical to the other trace routines.

In the next quarter, the CalComp should provide a rich new area for Library subroutines. Furthermore, the two which now exist are due for modifications and additions.

Besides the subroutine write-ups, two memoranda were distributed. They were:

Current Status of and Future Plans for ILLIAC II Subroutine Library — May 28, 1965

Concerning CalComp Library Routines — June 29, 1965

3.1.6 CalComp, Digital Incremental Plotter

In the middle of May, some members of the Department of Computer Science attended a CalComp user's conference in order to meet with people who had programming and hardware experience with the CalComp and to get ideas concerning the development of programs for the CalComp. Programming began as soon as the Plotter was received. Plotting operation is being done completely off-line via a low speed reading of a magnetic tape so as not to tie up ILLIAC II. Since incremental plotting steps are .005 inches, an accurate graph with fine resolution can be produced. The standard subroutines recommended by CalComp including Plot, Symbol, Number, Scale, Line, and Axis are being planned, programmed, or already modified.

3.1.7 Programs for Peripheral Hardware for ILLIAC II and SØC

Based on the early experience with SØC on the IBM 1050, a routine was developed to handle the many problems of control of the IBM 1050. The 1050 operator can now press buttons and type at will without causing ILLIAC II to hangup. Techniques used in the routine will eventually lead to hardware in the permanent 1050 registers that will handle the control problems.

A detailed simulator of the satellite processor has been written for ILLIAC II. All the basic orders and hardware items are included in the simulator so that the satellite processor assembler may be used. Test programs for the satellite processor are in the planning stage and will be coded soon.

SØC, the Simple Online Calculator program, was sufficiently debugged to allow it to be presented for public use for two one-half hour periods each day. Printed output from these public use periods give useful information for the planning of future console communication programs.

Publications from this quarter for the area include:

Title	Source	Date
Time-Sharing SØC on ILLIAC II	Prog. Memo. #9	May 3, 1965
Peripheral Processor Tasks for a Time-Sharing System on ILLIAC II	Prog. Memo. #10	May 6, 1965
Satellite Processor Simulators for a Time-Sharing System on ILLIAC II	Prog. Memo. #11	May 12, 1965

3.1.8 Program Plans

Other than finishing up existing programs, expanding the ILLIAC II library, correcting and adding to the FØRTRAN Compiler, developing the MACRØ PREPASS, and inserting the disk file package into the monitor, program plans lie mainly in the area of a 24-hour-a-day Time-Sharing System for ILLIAC II. Such a system is being developed in order to provide remote console immediate access to the computer as well as continue the batch processing mode and as a research project in the time-sharing field of computer science. A great deal of planning and discussion of such a system is now taking place through a documented interchange of ideas and possibilities. Study is being done especially in the areas of console-comcentre conflicts, the design of the monitor and executive programs, and the organization and use of the disk files. Gross design and definition followed by a detailing of the interfaces between the various packages and some flow charting should take place in the next quarter. Programming memoranda (P.M.) in this field include the following:

Title	Source	Date
Statement of Policy Concerning Planning of Software and Hardware for ILLIAC II as it Relates to the Service Group and the Peripheral Programming Group	Prog. Memo. #4	April 5, 1965
A Proposal for a Time-Sharing System on ILLIAC II	Prog. Memo. #5	April 21, 1965
The Interaction of System and Administrative Processors with SYSIØ and the Command Processor	Prog. Memo. #5.1	April 22, 1965
Numbering Input Lines in a File	Prog. Memo. #5.2	April 23, 1965
Making a SØC/JOSS Type Language Available to the Console User with a Fast Reaction Time	Prog. Memo. #5.3	April 23, 1965
Administrative Processors and Console Use	Prog. Memo. #5.4	April 23, 1965
ILLIAC II Time-Sharing Objectives and Schedule	Prog. Memo. #8	April 29, 1965
Some Simplifying Assumptions and Further Detail on Programs	Prog. Memo. #12	May 19, 1965
Disk File Organization and Use	Prog. Memo. #14	June 15, 1965
Thoughts on Off-line Input Tape Processing	Prog. Memo. #15	June 15, 1965

Section 3 of the Quarterly Progress Report has been written by J. Aaron, E. Brower, L. Byers, C. Carter, S. Chase, C. Ellis, C. W. Gear, L. Greninger, M. Haas, W. Huffman, D. Juran, J. Kelly, T. Kerkering, R. Kingsley, S. Krabbe, H. Lopeman, R. Miller, P. Neuhaus, A. Otis, F. Richardson, C. Shepard, T. Slivinski, and J. Watkins.

ILLIAC II LOG SUMMARY *

January, February, March, 1965

	January	February	March	Totals
ERROR ANALYSIS ILLIAC II				
Printed Circuit Boards	0	3	0	3
Advanced Control	2	2	3	7
Air Conditioning	0	1	0	1
Interplay	1	0	0	1
Drum	1	0	0	1
Core 0	2	10	6	18
Core 1	8	5	5	18
Main Arithmetic Unit	4	0	0	4
Delayed Control	5	0	0	5
Console	1	0	0	1
Selectrics	3	2	2	7
SRDP	1	0	1	2
PAU	1	0	1	2
1414 A	5	7	3	15
1414 B	0	2	3	5
1401 A	0	0	2	2
1301 A	0	1	2	3
Flow Gating	0	2	1	3
Power Supplies	5	16	8	29
Unknown	5	1	0	6
Interlock	1	1	0	2
Human Error	1	0	0	1
Tape Units	0	0	7	7
Punch	0	0	1	1
Special Registers	0	0	2	2
	46	53	47	146

* This table was inadvertently omitted from the previous Technical Progress Report.

3.2 ILLIAC II Engineering Log Summary

3.2.1 Error Analysis ILLIAC II

	April	May	June	Totals
Advanced Control	1	0	0	1
Air Conditioning	0	0	4	4
Console	0	0	1	1
Core 0	1	3	0	4
Core 1	3	0	1	4
Drum	1	1	6	8
Flow Gating	0	0	4	4
Interlock (CC14)	1	0	0	1
Interplay	2	1	1	4
I/O Power Supplies	4	7	5	16
NJE Power Supplies (Main Frame)	7	5	7	19
I/O Channels	5	8	6	19
Power Failures	0	*1	*3	*4
Reader	1	0	0	1
Unknown	0	4	0	4
Total	26	30	38	94

* Momentary or prolonged North Campus power failures.

3.2.2 IBM Equipment Requiring Services of Customer Engineer

Tape Drives	4	2	3	9
Selectric Typewriters	2	3	5	10
1402	0	2	0	2
1403	0	5	1	6
1406	0	1	0	1
7631-B	1	1	0	2
1301-B	1	0	0	1
Total	8	14	9	31

3.2.3 Scheduled Diagnostic Engineering

3.2.3.1 Maintenance

a.	Checking transistors	3 hours
b.	Marginal DC voltage tests	3 hours
c.	Checking collector, base bumps and zeners	9 hours
d.	Component replacement tests (Trying new transistors, semiconductors, etc., to replace obselete items)	3 hours
e.	Upgrading ILLIAC II (Emphasis was placed in April on finishing scheduled work on the main machine which will help maintenance and provide a more reliable machine)	74 hours
f.	Systematic component replacement (Capacitors and bad semiconductors)	12 hours
g.	Checking out spare chassis (Part of April emphasis for upgrading the machine	46 hours

3.2.3.2 Component Failures

a. Transistors in main machine (Main frame, core 1, Interplay, Drum and power supplies)

Main machine	40,121
Power supplies	3,592
Total	43,713
Transistors replaced	22

b. Semiconductors in main machine (Diodes, zeners, stabistors, etc.)

Total	81,946
Semiconductors replaced	7

c. Number of printed circuit cards in I/O equipment

Total	1,655
Replaced	16
Number with dirty contacts	2
Replaced due to burnt out lights	28
Total	46

3.2.4 Off-Line Equipment Requiring Repairs

Type	Name	Unit #	April	May	June	Total
026	Key Punches	06,12, 01,16, 01,15, 05,03, 01,07	3	6	1	10
056	Verifier		0	0	0	0
082	Sorter	01	0	1	0	1
514	Reproducer	01	2	0	2	4
557	Interpreter	01	0	1	0	1
1051	Print Keyboard	0C	0	0	1	1
1056	Card Reader	0A	0	0	1	1
804	Data Aux Set	0C	0	0	1	1
670	CalComp Plotter		-	-	1	1
	Total		5	8	7	20

TABLE I. ILLIAC II LOG SUMMARY--APRIL, MAY, JUNE, 1965

ILLIAC II Use

	April	May	June	Totals
ENGINEERING				
General Engineering	234:48	125:30	161:20	521:38
Core Engineering	3:00			3:00
Disk Engineering	40:17	65:25	89:26	195:08
1050 Engineering		1:31	:35	2:06
Drum Engineering			3:21	3:21
I/O Engineering			:10	:10
1414 Engineering			:20	:20
Sub totals	278:05	192:26	255:12	725:43
ENGINEERING TESTS				
AEC	142:35	229:17	223:53	595:45
KETPG	5:10	9:56	10:03	25:09
CREST		8:24		8:24
DAMN			:59	:59
Sub totals	147:45	247:37	234:55	630:17
PRODUCTION USE OF ILLIAC				
Code Checking, etc.	74:20	104:36	92:10	271:06
Math 195	5:51	13:24		19:15
Groups Use	205:24	178:09	125:13	508:46
Sub totals	285:35	296:09	217:23	799:07

TABLE I. ILLIAC II LOG SUMMARY--APRIL, MAY, JUNE, 1965 (Cont'd)

	April	May	June	Totals
MISCELLANEOUS				
Down	5:15	2:30	3:31	11:16
Power Off	:05		6:12	6:17
Idle	2:15	5:18	2:47	10:20
Wasted	1:00			1:00
Sub totals	8:35	7:48	12:30	28:53

Total Time in Operation for Quarter, 2184:00 Hours.

Percentage Analysis of Time for Quarter

Percentage of Time Used for Engineering	33:23
Percentage of Time Used for Engineering Tests	28:86
Percentage of Time Used for Productive Use	36:59
Percentage of Time Used for Down, Idle, Etc.	1:32
Total	100:00

TABLE II. IBM 1401 LOG SUMMARY--APRIL, MAY, JUNE, 1965

IBM 1401 Use	April	May	June	Total
ENGINEERING				
IBM Maintenance and Engineering	28:38	25:50	42:16	94:44
ILLIAC Engineering	5:20	5:40	17:28	28:28
Disk Engineering	6:30	10:53	31:12	48:35
Sub totals	40:28	42:23	90:56	173:47
ENGINEERING TESTS				
Core Worst	117:56	218:28	39:58	376:22
BTC		1:00		1:00
KETPG		1:32	1:57	3:29
Sub totals	117:56	221:00	41:55	380:51
PRODUCTIVE USE OF 1401				
ILLIAC Prep	278:15	324:35	220:47	823:37
Group Use	118:16	73:12	69:29	260:57
Off Line	33:32	30:03	60:42	124:51
Sub totals	430:03	427:50	350:58	1208:51

TABLE II. IBM 1401 LOG SUMMARY--APRIL, MAY, JUNE, 1965 (Cont'd)

	April	May	June	Total
MISCELLANEOUS				
Idle	124:33	52:47	231:00	408:20
Wasted	1:00			1:00
Down	6:00		5:11	11:11
Sub totals	131:33	52:47	236:11	420:31

Total Time in Operation for Quarter, 2184:00 Hours.

Percentage Analysis of Time for Quarter

Percentage of Time Used for Engineering	7:96
Percentage of Time Used for Engineering Tests	17:44
Percentage of Time Used for Productive Use	55:35
Percentage of Time Used for Idle, Wasted, Etc.	19:25
Total	100:00

4. COMPUTER SYSTEMS RESEARCH

(This work is supported in part by Contracts No. AT(11-1)-415 and No. AT(11-1)-1469 of the Atomic Energy Commission and in part by the University of Illinois.)

A variety of programs have been implemented and others are in progress to augment the Engineering Test Library of ILLIAC II. Participating in this work have been D. Bennett, H. Chelin, D. Chow, G. Huszar, F. Rohatsch and M. Levin.

4.1 Engineering Test Programming

4.1.1 Disk Bootstrap

Disk Bootstrap has been wired to read a bootstrap block from a disk file. The file contains the options presently available on drum bootstrap plus the on-line DEBUG program referred to below.

4.1.2 DEBUG

DEBUG is a simple on-line debugging program which provides a real-time man-machine interaction with ILLIAC II. With DEBUG, a user can see and/or modify the contents of any core location and then restart execution of his program without re-compiling. After return to the user's program, the computer is in the interruptable mode.

COMMUNICATION with ILLIAC II is by either typewriter, paper tape, or $SR76_8$, and all communication is in octal machine language. The program may be used with either the drum bootstrap or the disk bootstrap. The program is further discussed in:

"DEBUG: A Simple On-line Debugging Program," by H. Chelin, Department of Computer Science, File No. 668, June 25, 1965.

4.1.3 MEC (Multiple Program Engineering Control)

This program is to complement AEC (Automatic Engineering Control Systems Manual) in that it will make additional routines available to the master control of AEC from auxiliary storage areas. A File Number by D. Chow, describing this program is in preparation.

4.1.4 Tape Edit

A program intended for small scale modification of tape records has been written and is now working. A File Number by F. Rohatsch, describing this program is in preparation.

4.1.5 BONGOES

A complete set of magnetic drum tests is operational making it possible to check the drum in a variety of use modes. A File Number by G. Huszar, describing this program is in preparation.

4.1.6 Updating

(a) The store test (a part of AEC) was corrected and revised.

(b) OHM, the Open-House-Monitor has been revised to conform with changes in the 1050 (IBM Remote Console). A File Number by M. Levin, describing this program is in preparation.

(c) A subroutine, CLØCK, to use the Real Time Decimal Clock as a service device for timing long periods of time has been written by M. Levin.

4.1.7 AEC (Automatic Engineering Control)

The final compiling, editing and internal publishing of an Automatic Engineering Control Systems Manual has been completed. It is to serve as a description of the (AEC) control system as of June, 1965, and has been written and edited by J. Bouknight, G. Cooper, G. Huszar and M. Levin.

4.2 Time-Sharing Programming

4.2.1 CLIC

This file* is concerned with the set of subcommands associated with CLIC. Specifications and details may be found in TSPG (Time-Sharing Program Group) publications noted in Appendix I of this File Number. This list will be added to from time to time as CLIC is expanded and some of the references may as yet not be complete.

4.2.2 The Concept of an Editable Compiler Language

Recently there has been a great upsurge in the use of computers in an on-line or conversational manner. This coupled with the availability of economical large capacity storage devices and the desire on the part of many users for more flexibility in operation has opened the door to the introduction of new software techniques.

There are several areas of computation where the traditional batch processing system has become a cumbersome device. One significant problem of the batch processing system is that of time consuming multiple compilations, code checks, and debug sessions at the initial writing or modification of a program. This and the inability in a batch processor to make minor modifications to the program without disrupting the computation in progress and restarting the calculation has led to systems and programs where elaborate precautions are taken to anticipate every eventuality. Even then, the seriousness of this problem is directly dependent upon the quality of the programmer and the clarity of definition of his problem. It is very easy to find a problem in which the technique of computation should be changed in an unanticipated manner after significant computation has been accomplished.

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* "The Subcommand Language for the CLIC Subsystem in the ILLIAC II Time-Sharing System (ITSS)", by J. Bouknight. DCS File No. 659. May 12, 1965.

Another area of great significance to this discussion is the area of real time digital control. In this situation it is often necessary or desirable to modify the control programs with little loss of time and no loss of data.

A third problem is that of restart. In any large computation it is necessary to provide restart procedures to accommodate long term computational and machine failures.

In the situations mentioned above a large amount of man and machine time is lost through unnecessary and sometimes frustrating procedures. The solution proposed in this paper cannot accommodate machine failure, but it can produce a savings of time and effort through increased man-machine interaction and communication.

Basically, what is proposed has twofold impact. First, a system will be described which automatically retains the user's data while he is modifying his program. Second, this system will be designed so that modifications to a program are made by presenting the system with only the minimal information required to perform the modification while at the same time allowing the user access to the maximal information as to the state of his computation.

Some definitions of terminology must be made. The overall computer environment will be called the system. Internal to the system we shall consider the source language which the user inputs, an intermediate language into which this source language can be translated, the object code which is the result of the source language translated into intermediate language and then to object machine code, the tables describing the program to the compiler, and, finally, a certain number of executive or system routines to which the user has access. When a general term is desired, the source language, intermediate language, and object code will all be grouped under the designation of program.

The user can be concerned with either an on-line input/output device (time-sharing or not) or the more common situation of hard copy input and output. In either case he should be able to input a program in a convenient language, compile this program (separately or simultaneously with input), and then execute the program. Now if he wishes to, he may stop execution and modify any portion of the program and restart execution at whatever point he wishes. In spite of

his modification, all of his data will be retained and the modified program will properly operate on his data according to his program. However, he is responsible for properly defining the initial values of any new variables introduced by his modification.

Some of the requirements for such a compiler are already apparent. First, sufficient information must be retained for the compiler to modify the program. Second, the user's data must be retained.

Specifically, what is required is a system where all information concerning any particular program is retained by the system for the user. By all information, it is meant that three categories of information be retained: 1) the user's source program as he has modified it; (This is necessary to give the user a listing of his program in its current state.) 2) sufficient intermediate compiler information to permit modification of the object program and still permit reference to the same data structure, or alternatively, enough information to revise the data structure to the modified program; and 3) the user's data retained in the state he put it.

Several recent systems, the most notable of which is Project MAC, have some aspects of this idea. The major innovation which is proposed here is the retention of object time data in spite of a modification to the object program.

For the proposed system, decisions must be made on several issues. First, what is a definition of the appearance of the language to the user? Second, should the system actually use an interpreter instead of a compiler? Third, in what form and where does the system store the intermediate language results? Finally, where is the user's data stored, and is its structure ever modified?

The external appearance of the language first must be divided into at least two sub-groups, the language proper and a control language. The language proper ideally should allow any computation language desired. As for the control language, it must provide two things, the ability to control compilation and modification, and the ability to control execution of the object program.

The answer to the question of an interpreter versus an actual code compiler lies at the heart of the reasons for an editable compiler. The purpose of an editable compiler language is to allow a user to compile a program, execute it for some time, this time possibly being several actual hours of computation, then modify the program without the loss of the computation to date, and continue the calculation. Since a long period of calculation is possible before modification takes place, it does not seem advisable to throw away a large percentage of this time in an interpretation routine. Therefore, although an interpreter would be the easiest way to accomplish the desired results, its inherent inefficiencies lead one to immediately discard this solution. This decision leaves the choice of an actual code compiler or some form of intermediate language.

These alternatives must lead to a discussion of partial or total compilation. That is, is it desirable to completely recompile the program at each modification but retain the same data storage allocation, or should one attempt to only recompile the changed portions of the program? Completely recompiling but retaining the same data base requires starting the compilation with the data base (symbol table) already constructed. If the actual data is saved and then replaced after the recompilation with the same data base all should be well. However, a result of the modification procedure might be portions of the data area which are no longer referenced. A special procedure in the form of an auxiliary table of data area usage would be required to utilize such voids in the data area.

On the other hand, why is it necessary to totally recompile? The portions of the program which have not been modified will produce the same code (with allowances for inter-statement optimization, etc.), at most slightly displaced in memory, and if we can allow slight inefficiencies by restricting the optimization, it is possible to produce object code which is globally invariant as a result of optimization.

If we are to partially recompile, we must decide upon the intermediate language to use, for there must be some form of intermediate results to relate the source language to the resulting object code. When a change is made in the

source language, a corresponding change must be made to the intermediate language and ultimately in the object code. It appears, then, to be a waste to totally recompile when large portions of the result could be the same. (Remember at this point that this paper is concerned with modifications to a program, as opposed to rewriting a program.)

The relation between source language, intermediate language, and object code can take several forms; however, for reasons of efficiency it appears to be prudent to restrict the system to intermediate languages of machine code or at most augmented machine code, and to retain the other facts necessary to provide the relation between the source language and the object code in tables. That is, the intermediate language can be considered to be the object code supplemented by tables. This allows one to execute the intermediate language without having a third independent description (source language, intermediate language, object code) of the user's program.

In order to intelligently discuss what should be kept as intermediate results, some thought must be given to the type of information which must be retained and the operations which must be performed to modify the program. First, let the object language structure be divided into four parts: 1) the object code; 2) the data area; 3) the subroutines; and 4) the supervisory system. (The supervisory system will be just another subroutine for all these purposes.) Then a statement in a program can: 1) reference any point in the data area; 2) refer to another statement of the program; or 3) refer to a subroutine. Therefore, each time a program is modified, it can: 1) define or "undefine" some of the data area; 2) create and destroy segments of the object code; 3) require or no longer need the use of subroutines; 4) modify the logical structure of the program.

First, consider the data area. Since the source language will use a symbolic addressing scheme, at least the correspondence of symbolic name to data area location must be retained. However, if we are to keep account of the use of the data area and make economical use of it, a record of which portions of the data area are used by the object program is desirable. Therefore, how many times each portion of the data area was referenced should be retained. An alternative to this is to keep a list of each point in the object code from which a given portion of the data area is referenced. This, however, leads to large tables.

The problem of overflowing the data area when a large group of modifications call for data area assignments or alternatively of rearranging it must be kept in mind. This makes a complete reference table of all usages more attractive, since all data references can be rearranged without recompiling. Another possibility of the same nature is the indirect referencing of all of the data area, which again allows rearrangement of the data references without recompiling. Either of the above techniques is somewhat cumbersome and slower in execution than direct reference to the data area; however, the advantages are apparent in situations where the data area must be redefined. Some though must be given to these techniques in a language where the data area definitions are of primary interest.

The idea of the data structure rearrangement is also related to the control segment. Besides allowing the user to modify the data values aside from the actual program, he might desire the ability to equivalence two symbols or declare that a symbol within a certain section of the program is no longer related to the same symbol elsewhere in the program. This aspect of compiler languages wreaks havoc with a modification scheme using absolute data area assignments. This area of control function modification along with mode declaration, equivalence statements, file definition statements, etc., generally has far reaching effects when they are utilized in a compiler language. The modification, introduction, or deletion of such a statement or its equivalent control mode could conceivably require a change in every portion of the object code. This type of statement will always reopen the debate over total recompilation in the same data base versus modification.

Another nontrivial portion of this discussion concerns how to subdivide the object code and how to relate the points in the object code to the source language. This problem becomes extreme when it is noted that there is no one-to-one correspondence between source language and object code. In fact, in some source languages, one small portion of the input program conceivably can produce almost all of the resultant object code or no object code at all. With such extremes, the practical approach of finding natural breaks for each language used must be taken. For example, in algorithmic languages, each matched pair of delimiters can be considered as enclosing a convenient sub-group

or the input could be subdivided as small as individual operators and operands. The size of the individual segments can vary to the extremes of single operators and operands or the whole program at once. This decision is somewhat arbitrary.

Consideration must be given to the size and manageability of these segments. Surely the whole program is too large a segment, since this segmentation is the same as total recompilation for each modification. On the other hand, the segmentation into individual operators and operands appears to be too fine a division. In light of the next topic to be discussed, a convenient subdivision appears to be any block which can be referred to by another portion of the program (i.e., a portion which can have a label affixed).

In considering labels, another major problem of allowing modification of a program is encountered. This is the problem of the definition, "undefinition," and movement of labels. In the course of his modifications the user could conceivably produce something which is not a proper program. He could do this either by leaving off a required label, defining a label twice, or arranging a transfer of control sequence in such a manner that it violated the restrictions of the particular language of concern.

The problem of a reference to an undefined label provides the need for some sort of transfer checking table, possibly quite similar to the techniques used in forward transfer linking in an ordinary compiler.

It appears easiest to forbid the situation of the double definition of a label; however, that produces an annoying burden on the user. The simple act of moving a label must be a deletion of the label followed by the addition of the label in the new position if the problem of double definition is to be avoided. This could be done internally by providing the user with a control function to move a label. Of course the other approach is to allow multiple definition of labels, but with full information given to the user. In either event, when a label or labels are multiply defined, the system can notify the user of the problem and either refuse to let him execute or allow him to execute and notify him when he comes to an unresolvable point because the program is not proper. The latter point might have some good properties, since it would allow the user

to delete program segments by deleting just the entry to that portion without removing the whole segment. Also, he could safely execute an improper program with the knowledge that the system would accommodate the situation.

Whatever course is taken, a record must be kept of the program structure as it currently exists, so that it can be edited with accuracy and speed.

Another point to discuss is that of subroutines. The simple idea of requiring or no longer requiring a certain subroutine is a minor point. Of more concern are the side effects of subroutines. They can modify data, transfer control, and even redefine the data area. The absolutely sure way of handling these problems is the complete cataloging of the subroutine properties and accounting for each call to a subroutine with significant side effects by appropriate modifications of the intermediate language information. An alternative is the restriction of the properties of subroutines which may be used with the editable compiler language. If the user is made responsible for the changes these subroutines produce in his data, these restrictions on subroutines do not have to be very severe.

The other topic which must be discussed in this introduction concerns further handling of user data. If the user is to be allowed to start and stop execution, he must be able to start where he wishes and stop whenever or wherever he wishes with full knowledge of where he stopped. It is only reasonable therefore, to expect the user to wish to view portions of his data or to modify his data externally to his program. This should be treated as a control function.

The control functions should also give the user the ability to make nonpermanent modifications or trial modifications. The object program structure should be dependent upon the data to such an extent that the user can simply say, "Save my data," compute or modify the program and data as he wishes, and at any later time be able to return to the saved data set.

In the same light, it might not be unreasonable for the user to wish the same storage and restoration privileges with program as he has with data, both as a restart feature, and as an experimental convenience.

Many reasons and justifications for an editable language have been brought forth on the preceding pages. These ideas have strong concepts embedded in them, but were necessarily devoid of details since too little has been defined about the language structure which is usable in such a system. Succeeding investigation will remedy these faults and provide some concrete suggestions for a language structure and associated system capabilities.

4.3 Equipment Descriptions

4.3.1 Disk File Interplay Channel

Debugging of the channel has reached the stage where each command functions properly; however, the channel cannot be termed reliable. Most of the work to date has been directed towards eliminating the problems in equipment built by the Department of Computer Science; consequently, less than one per cent of the total disk file data surface has been used. It has been necessary, furthermore, to borrow parts from one disk file in order for the other disk file to function. Changes to the command structure of the channel are being documented.

Engineering on the Disk File Channel is becoming, largely, a programming effort. Several options normally given to disk file users, such as format specifications, will be reserved for system/engineering programming changes; the required engineering programs are currently being written.

A general program to test the memory properties of the disk file is being written. This program will test the entire data surface for bad spots and frequency sensitivity and will facilitate amplifier adjustments, etc.

The third engineering programming area being pursued is maintenance programming. The approach used here is to generate many simple programs, each of which uses a minimal amount of the Channel's hardware--this is a first-order attempt at fault-location programming.

An analysis has been made of the cost of increasing the data transmission rate by logical changes to the file control and to the file itself. The cost is exorbitant; since the speedup technique analyzed seemed to be the most promising, the disk file speedup project will not be further pursued. The cost estimates are contained in:

"One Possibility for Speedup of Data Transmission Rates of Disk File Channels," by Y. T. Yen, DCS File No. 662, June 1, 1965.

4.3.2 Magnetic Tape Interplay Channels

The IBM 1414 Tape Unit Synchronizers used on ILLIAC II differ from standard 1414's. The changes made to the 1414's by the Department of Computer Science, and the reasoning behind the changes, are documented in:

"Internal Modifications--IBM 1414 Mod VII," by R. E. Willard, DCS File No. 674, June 21, 1965.

4.3.3 Data Set Design

A full duplex data set has been designed which provides for channelization of the telephone line for the simultaneous use of several data sets. The data set can be coupled to leased telephone lines and is suitable for accoustical coupling via standard telephones. The design is described and discussed in:

"Data Set for Low-Speed Remote Terminals," by E. D. Crockett, DCS File No. 669, June 24, 1965.

4.3.4 Real-Time Decimal Clock

A Real-Time Decimal Clock System has been added to ILLIAC II to facilitate automatic accounting and to supply timing markers for console logging comments. This clock, from the viewpoint of ILLIAC II, is a 24-hour clock with a resolution of 0.1 seconds; clock readings are in IBM BCD format, with hardware

zero-suppression. In order to isolate the clock from failures of ILLIAC II, separate power supplies are used. The clock system is further explained in:

"The Real-Time Decimal Clock System on ILLIAC II," by J. Bouknight, DCS File No. 661, June 7, 1965.

4.3.5 Electrochemical Memory Research

A read-mostly digital computer memory model has been investigated using chemical cells as binary memory elements. A word-organized array of special low-charge cells has been coupled to drivers and logic to form an operational regenerating memory. This investigation, based on previous work done at the Department of Computer Science by B. E. Briley, is described in:

"Experiments in the Use of the Electrochemical Cell as a Binary Memory Element," by R. E. Hasselbring, DCS Report No. 180, June 2, 1965.

4.3.6 Teletype Special Register

The logic design of the Teletype Special Register, mentioned in the previous Quarterly Technical Progress Report, has been constructed and is nearly operational. A Teletype Model 33 KSR has been connected to this register in a DC loop mode for test purposes. A successful read-around test has been run; however, two problems remain: input (Teletype to ILLIAC) at the maximum Teletype speed causes errors, and output characters are lost under some circumstances. Neither of these problems appears insoluble.

4.3.7 Satellite Processor Communications System

A great deal of time was spent during this past quarter in solidifying the specifications for a Satellite Processor Communications System for ILLIAC II. This system is intended to handle communications between ILLIAC II and many remote consoles, in a time-shared environment. Since it is intended that this

peripheral system do buffering and pre-processing of ILLIAC-console dialog, the system must have many properties of a general-purpose computer, as well as the requisite properties of a real-time communications system.

A state-of-the-art survey, previously conducted by the Computer Search Group* of the Department of Computer Science, showed two machines to be eminently suited to the purposes of this system; these machines, along with their software and documentation, were examined by C. W. Gear and R. E. Willard during a trip to the respective plants in April, 1965.

The various investigations culminated in three publications:

"Proposal: Satellite Processor Communications System for ILLIAC II," by C. E. Carter and R. E. Willard, DCS File No. 652, April 30, 1965.

"General Descriptions of a Satellite Processor for ILLIAC II," by C. E. Carter and R. E. Willard, DCS File No. 654, May 12, 1965.

"Procurement Specifications for a Satellite Processor Communications System for ILLIAC II," by C. E. Carter and R. E. Willard, DCS File No. 550-56, May 14, 1965.

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* See the Quarterly Technical Progress Report for the last quarter of 1964.

4.4 ILLIAC II General

In order to increase the availability of information about ILLIAC II, a brief bibliography has been prepared.[1] The bibliography lists papers describing ILLIAC II which were published in the open literature plus Department of Computer Science Reports, since these also are fairly widely distributed. Department of Computer Science File Numbers and other internal documents were not listed.

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[1] H. C. Brearley, Jr., "ILLIAC II--A Short Description and Annotated Bibliography," IEEE Transactions on Electronic Computers, Vol. EC-14, No. 3, June, 1965.

5. COMPUTATIONAL PHYSICS

The Wiener integral formulation combined with Monte Carlo sampling has been used to compute the two-particle Slater sum for He_4 for temperatures ranging from 273° K down to 2° K, the lower practical limit for this computational method. This is equivalent to a calculation of the density independent part of the pair distribution function. A Lennard-Jones 6-12 potential has been used to describe the interaction. Contributions from exchange were found negligible at 5° K and above. Comparisons with the Wigner-Kirkwood expansion are made. The second virial coefficients derived from these results are within two per cent or three per cent of the results obtained from the usual phase shift calculation.[1]

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[1] Abstract from "Path Integral Calculation of the Two-Particle Slater Sum for $He_4^{\dagger}$," by Lloyd D. Fosdick and Harry F. Jordan, Department of Computer Science, University of Illinois, Urbana, Illinois, Report No. 186, August, 1965.

6. IBM 7094-1401 SYSTEM

(Supported in part by the National Science Foundation under Grant No. NSF-GP-700.)

6.1 New Routines

M2-UOI-CNV3-55-SR

One Word BCD to Column Binary Conversion Routine, for SCATRE, MAD, and FORTRAN programs. To permit hollerith information to appear in a column binary card, where it may be interpreted.

A simple table lookup procedure is used.

Adapted by Keith Rich and
Martin Minow

Revised by F. Benard
May 13, 1965

B1-UOI-DATN-51-SRX

Floating Point Double Precision Arctangent. FØRTRAN, SCATRE, and MAD. This program computes the double precision principal value of arctan x for a double precision floating point number x.

Programmed by Eugene Y. Chang

Revised by James D. Ahlstrom
May 10, 1965

B3-UOI-DEX1-41-SR

Double Precision Floating Point Exponential. SCATRE, FØRTRAN, and MAD. This program computes in double precision floating point 2^x, e^x, or 10^x where x is a double precision floating point number.

Programmed by David Hutchinson

Revised by James D. Ahlstrom
May 12, 1965

B3-UOI-DLN1-42-SR

Double Precision Natural Logarithm. SCATRE, FØRTRAN, and MAD. This program computes the double precision natural logarithm of a positive normalized double precision floating point number.

Programmed by David Hutchinson
Revised by James D. Ahlstrom
May 11, 1965

B1-UOI-DSIN-47-SR

Double Precision Floating Point Sine and Cosine, for SCATRE, FØRTRAN, and MAD programs. This program computes the double precision floating point sine or cosine of a double precision floating point argument in radians.

Programmed by David Hutchinson
Revised by James D. Ahlstrom
May 10, 1965

B4-UOI-DSQRT-39-SR

Double Precision Floating Point Square Root. SCATRE, FØRTRAN, and MAD. To compute the positive square root of a normalized nonnegative double precision floating point number.

Programmed by David Hutchinson
Revised by James D. Ahlstrom
May 10, 1965

B3-UOI-EXP1-79-SR

EXP1 raises an integer base to an integer power. For SCATRE programs only.

Programmed by F. Benard
May 12, 1965

Q1-UOI-FPT2-80-SR

Floating Point Trap Processor, for use primarily with FØRTRAN programs, but applicable also to MAD and SCATRE programs. To provide for the processing of floating point traps according to the rules specified in the IBM 7090/7094 FØRTRAN II Programming Manual.

Programmed by David Hutchinson
George Friedman

May 12, 1965

C3-UOI-IEF1-77-SR

IEF1 evaluates the incomplete elliptic integrals of the first and second kind for a given amplitude PHI and modulus XK, for MAD, FØRTRAN, and SCATRE programs.

Programmed by Fran Benard

May 28, 1965

G5-UOI-RAN3-82-SR

To generate a sequence of pseudo-random floating point numbers or full-word integers which appears to have been drawn at random from a population which is uniformly distributed.

A method of Professor D. H. Lehmer (University of California, Berkeley) is used to generate uniform pseudo-random integers on the interval $[1, 2^{35}-32]$.

Programmed by David Hutchinson

May 13, 1965

D2-UOI-RKY5-78-SR

Integration of Ordinary Differential Equations by the Runge-Kutta Method, for SCATRE, MAD, and FØRTRAN programs. A fourth order Runge-Kutta method is used.

June 4, 1965

B2-U0I-TNH1-81-SR

This subroutine computes the hyperbolic tangent of a floating point number X.

The exponential of 2X, EXP(2X), is first computed and the hyperbolic tangent of X is then obtained from the identity

$$\tanh X = \frac{e^{2X} - 1}{e^{2X} + 1}$$

Provision is made to give

tanh X = X if X is small (<0.00034)

tanh X = 1.0 if X is large (> 12.0)

Adapted from University of Michigan Subroutine Library

May 13, 1965

F5-U0I-XNV1-83-SR

Inversion of a real symmetric matrix by the method of a successive bordering. The determinant is automatically computed and returned as a byproduct.

Adapted from Michigan subroutines by Ann Wilkinson

Checked by Mike Pershing

June 5, 1965

G5-U0I-DEV2-75-SR

To generate a sequence of pseudo-random floating point numbers which appears to have been drawn at random from a normally distributed population with mean zero and variance one.

Programmed by David Hutchinson

April 28, 1965

Q1-U0I-FPT1-65-SR (revised)

Floating Point Trap Processer, for use with MAD, FØRTRAN, and SCATRE programs, to provide for complete programmer control over the processing of floating point traps; two new features have been added to facilitate specification of trap processing.

Programmed by David Hutchinson
John Ehrman
George Friedman

April 28, 1965
Previous version dated December 3, 1964

L1-UOI-GTLD1-72-SR

This routine calls the System Loader during Execution Time. GTLD1 makes it possible to load programs generated either before or during execution time, or to complete the loading of a partially loaded ping-pong record, all under a flexible parameter control.

GTLD1 rearranges the parameters of the calling sequence into the loading block used by the Loader and then uses SYSLSR to call the System Loader from the System tape.

Programmed by Freda Fischer
March 30, 1965

D1-UOI-PW-70-SR

Sets of points (abscissas) and weights to be used in numerical integration. These short subroutines supply sets of points and weights to routines performing approximate numerical integration of definite integrals. Since a variety of types of integration may be performed by a procedure such as

$$\int_a^b F(x)dx = \sum_{k=1}^{N} A_k F(x_k) + R_N,$$

each type of one-dimensional integration formula is described separately, followed by a list of available sets of points and weights.

April 30, 1965

D1-UOI-QUA1-57-SR

Evaluation of One-Dimensional Definite Integrals by Mechanical Quadrature, for SCATRE, MAD, and FØRTRAN Programs. A great variety of one-dimensional integration formulas may be written in the form

$$\int_a^b F(x)\,dx = \sum_{k=1}^{N} A_k F(x_k) + R_N$$

where (a,b) is the interval of integration, F(x) is the function to be integrated, the x_k are the "points" (or "abscissas") at which F(x) will be evaluated, the A_k are the "weights" to be given to each evaluation, N is the number of evaluations to be made of F(x), and R_N is the approximation error involved in using the integration scheme.

A complete description of the sets of points and weights available for use with QUA1 is given elsewhere. These descriptions also include suggestions for the transformation of integrals to nonstandard intervals, error estimates for various formulas, and so forth.

Programmed by Dr. John Ehrman
March 31, 1965

G5-UOI-RAN2-76-SR

To generate a sequence of pseudo-random floating point numbers or full-word integers which appear to have been drawn at random from a population which is uniformly distributed.

Programmed by David Hutchinson
May 3, 1965

6.2 Problem Specification

During the second quarter of 1965, 140 problem specifications were submitted to the IBM 7094 for computation. The following brief descriptions of these problems have been prepared for inclusion in this report by those submitting them. T indicates a calculation associated with a theses.

1399-54003 Food Science. Continuity Equation for Ultra Centrifuge. This problem requires the integration of the continuity equation for sedimenting and simultaneously polymerizing substances in the ultra-centrifuge with the purpose of establishing the shape of the sedimenting boundary of α_s - casein C.

The continuity equation for a sedimenting substance undergoing simultaneously di-, tri-, tetra- and pentamerization can be written as a set of partial differential equations relating the concentrations of the various monomers, sedimentation coefficients, angular velocity of the centrifuge, radial coordinates, and time. Because no explicit expression for the solution is known, various least-squares approximations to terms in the equations will be required, which will then be solved by the method of characteristics with a number of initial conditions. (Theodore Payens)

1400-54004 Horticulture. Market Grades and Standards for Cut Roses. The problem is to identify factors determining quality in the important commercial varieties and types of cut roses, and to develop specifications for market grades and standards for these varieties and types of cut roses. Ten different measurements were made on 8 stem lengths of Better Times roses over a period of 13 months. The computer will be used to analyze the data and to select those quality factors that best correlate with increase in stem length. The data will also be analyzed for the effect of seasonal variation due to environmental changes on those quality factors. (Culbert)

1401-54005 Civil Engineering. Dynamic Response of Systems With a General Bilinear Resistance. The dynamic response of simple systems with a general bilinear hysteretic restoring force to several realistic earthquake type disturbances are to be investigated. The primary objective will be to determine the effect of a symmetry in the restoring force on the maximum deformation experienced by the systems. (S. J. Fenves)

1402-54006 Dairy Science. Statistical Analysis of Dairy Physiological Data. Part of the usage will be devoted to least squares analysis of variance of dairy physiological data. This includes computing estimates of experimental design variables ("fitting constants"), determining their standard errors and statistical significance; fitting orthogonal regression coefficients; computing analyses of covariance; computing mean squares and F-ratios for categories of variance; and related statistics.

The remainder of the machine time, it is anticipated, will be used in revising some existing statistical analysis programs currently used in the department to make them more efficient and more generally applicable. (G. W. Salisbury)

1403-54007 Agronomy. Systems of Alfalfa Establishment. The purpose of this problem is to study the effects of a) the stage of development in which an oat companion crop is removed, b) the variety of oats used, c) the seeding rate of oats used, d) the variety of alfalfa used, and e) the level of nitrogen fertilizer applied, on the yields of oats and alfalfa in the year of seeding and on the yield of alfalfa in subsequent years. The computer will be utilized to perform the necessary analyses of variance for which programs are currently available. (Pardee)

1404-54008 T Agricultural Economics. Econometric Analysis of the Wheat Sector. "Forecasting by Econometric Systems", a program developed by H. Eisenpress of IBM and modified by Professor V. I. West of the Department of Agricultural Economics of the University of Illinois will be employed as a basis for estimating the parameters of economic behavior relations that are contained in alternative models of the wheat sector of the economy. (J. Slater)

1405-54010 T Agricultural Economics. Sampling Properties of Restricted Estimators. A quadiatic programming routine will be used in conjunction with simulation procedures for deriving the sampling properties of inequality restricted estimators. (T. C. Lee)

1406-54011 Agricultural Economics. Linear Programming Transportation Code. A computer program based on the Dantzig linear programming transportation algorithm, will be developed to handle the problem of optimal geographical flows when regional demands, supplies, and transportation costs are given. (G. Judge)

1407-54012 T Agricultural Economics. Spatial Equilibrium Models. The LP/90 programming routine will be used in the estimation of models depicting the optimum regional levels of production, price, and geographical flows in the feed-livestock sector of the economy. (H. E. Buchholz)

1408-54013 Chemistry and Chemical Engineering. Protein Conformation. The experimental data are values of various physical quantities (light absorption, light emission, temperature, ion concentrations) relating to proteins in solution. It will be attempted to obtain correlation of the observed values with those calculated under the assumption of the existence of several forms of protein (different conformations) in solution, each with characteristic properties. Only the most standard mathematical approach will be required. (Gregorio Weber)

1409-54015 Chemistry and Chemical Engineering. Non-Reacting Shock Calculations. The purpose of the program is to calculate temperature, pressure, and density changes that occur in a shock wave. The parameters are for both the incident and reflected shock regions, assuming no reaction has taken place. No new mathematical techniques are used in the computation; the only information required by the program is: heat capacity data; initial temperature, pressure and density; the equation of state; and the shock velocity. (R. L. Belford)

1410-54016 T Theoretical and Applied Mechanics. Stability of Viscoelastic Column. When an initially straight, simply supported, viscoelastic column is subjected to an axial load consisting of a static component plus a component which varies harmonically with time, it is possible to have sustained lateral vibrations for certain values of the system parameters. This notion is governed by third and fourth order ordinary,

linear differential equations with periodic coefficients. These equations are solved approximately by a combination of the method of variation of parameters and perturbation methods. In the solution of the equations it is necessary to normalize the system such that a certain matrix becomes a diagonal matrix. In doing this there is numerous computations and matrix multiplications. The computer will be used to perform this computation. Explicit equations are known for all steps of the computation and no special mathematical methods are involved. (K. K. Stevens)

1411-54017 Industrial Engineering. Production Scheduling. The problem is to determine optimum (minimum cost) monthly levels of production, work force, and inventory for a firm over a planning horizon of 34 months, given certain initial conditions and sales forecast data.

The problem involves the solution of a large set of linear algebraic equations. (David Giffin)

1412-54018 Agricultural Economics. Ag Investments in Ulucak. Data on schedules taken in a survey of villagers in Ulucak, Turkey will be used to estimate (1) optimum resource combinations on representative farms, and (2) optimum investment and allocation plans for the representative farms and for the village as a whole. Regression methods will be used to attain objective (1); linear programming methods to attain objective (2). (Lyle Fettig)

1413-54020 T Economics. The Shifting of Federal Excise Taxes. There is some debate among economists about who bears the burden of Federal Excise taxes. With statistical techniques, conclusions can be drawn concerning who does bear the burden due to Federal Excise Taxes. The computer will be used to carry out these statistical operations. (James Truitt)

1414-54021 T Educational Psychology. Role of Experiencing Variables in Ψ-Therapy. Rating data from the Wisconsin Psychiatric Institute is to be used to obtain correlational analysis between the 12 criterion variables and a set of prepost test change scores. The results will indicate the usefulness of "Experiencing Variables" in predicting the course of therapy. (Ryan)

1415-54022 Recreation. Lawrenceville Recreation Survey. The study is an investigation of the recreation behavior, interests, and attitudes of adult and teenage subpopulations of a small city. The computer will be used to intercorrelate the variables of the study and perform statistical significance tests on them, e.g., analysis of variance. (William G. Keating)

1416-54023 T Chemistry and Chemical Engineering. Diatomics in Lattices. The properties of diatomic molecules, isolated in host lattices of various symmetries, are being studied. Of particular interest is the barrier to rotation of the diatomic molecule originating in the molecule - lattice interactions. These interactions are treated as a perturbation on the rotational energy levels of the free diatomic molecule. Standard first order perturbation theory is used and a wide range of barrier parameters chosen so as to generate the desired levels. The theory is tested by taking the vibration-rotation spectra of the diatomic molecule and fitting the absorbtions to the predicted levels. (M. T. Bowers)

1417-54025 T Aeronautical and Astronautical Engineering. Temperature Distribution in a Sphere with a Moving Boundary. The computer is to be used to solve the best conduction equation (parabolic) when the solid has a moving boundary. By the method of finite differences the temperature profiles and position of the moving boundary will be obtained. Since the material properties of the solid are a function of temperature, there will have to be on iteration scheme used until convergence occurs. (Richard Hurwitz)

1418-54026 Civil Engineering. Cylindrical Problems of Elastic-Plastic Material. This research concerns the solution of quasi-static equilibrium problems in a solid which is externally loaded and obeys elastic-perfectly plastic stress-strain laws. The solid will be approximated by a lumped-parameter mathematical model. Equilibrium is established for each element of the model according to appropriate stress-strain laws by a relaxation process. During inelastic action the stress-strain laws are of a rate form which requires the solid to be loaded in small increments. Each increment of loading requires use of the relaxation process. Therefore a high level of loading requires the process to be used many times. This would require many man-hours of hand computation and would thus be prohibitive. The computer

will be programmed to perform the entire computational process involved in computing stresses and strains throughout the solid, as well as the relaxation process. (L. D. Green)

1419-54027 T Chemistry and Chemical Engineering. Evaluation of Mössbauer Data. From the Mössbauer apparatus one obtains spectra which consist of either one peak, two peaks, or six peaks. These spectra must be fit by a least squares calculation for Lorentzian-shaped peaks. (H. G. Drickamer)

1420-54028 T Physical Education for Men and Graduate PE. Fitness of Fencers. The significance of the difference between means on the same tests given before and after a season of Varsity Fencing will be examined. A test with pooled variance is to be used. (Bill LaPietra)

1421-54029 Agricultural Economics. Flow of funds in American Agriculture. Research Project: Analysis of Impacts and Interations of Major Government Programs Affecting Agriculture.

The objectives of the study are to investigate impacts and interactions of selected major programs affecting agriculture on use of resources, level and structure of output, level and distribution of income, formation and distribution of capital, as well as in relation to general economic growth of the economy.

In this phase, the procedures are to make an inventory of expenditures of public monies which can be classified as direct or indirect support to agriculture, and to ascertain by what types of analysis these problems can be treated, having in mind the interactions and repercussions between agriculture and the country's economy in general.

The computer would be used mainly for time series decomposition and regression analysis, that is, to adjust seasonal and irregular time series to a form that shows primarily the trend-cyclical movements and to establish relationships between the movements over time of the explanatory variables used in the analysis. (Gottfried Ablasser)

1422-54030 T Electrical Engineering. Calculation of Propagation Constant. This problem is the solution of the determinantal equation for the propagation constant along a sinusoidal conducting tape. The tape is assumed infinite in the z-direction and lying in the x-z plane. The equation for the propagation

constant is arrived at by setting the tangential E-field equal to zero on both edges of the tape. An infinite determinant set equal to zero is the resulting equation. What is desired is to find an attenuation constant, alpha, and a phase constant, beta, which will make the infinite determinant zero.

Each entry of the infinite determinant is an infinite series of integrals over the range minus infinity to plus infinity. The integrands of each of these integrals are rather complicated functions of high order Bessel function produces, roots of complex numbers, and powers and sums of complex numbers. Analytic evaluation of the integrals has proven impossible, while numerical calculation by hand is completely impractical.

To solve the equation on the computer, first the determinant has been truncated to three by three, second, the infinite sums truncated to -43 to +43, and third, the integration range truncated to -500 to +500. A 40 point Gauss-Legendre formula is used to evaluate the integrals over the range 0 to +500, the negative range is had by symmetry considerations. A first guess is put in for the complex propagation constant and the determinant is computed. If both the real and imaginary parts of the determinant are not less than a specified small number, the computer proceeds to use a Newton-Ralphson iteration scheme to get a second approximation to alpha and beta. This process continues until convergence is achieved or a certain maximum number of iterations is reached whereupon the machine reads another data card for a new frequency and new first guesses for alpha and beta.
(J. W. Greiser)

1423-54031 T Chemistry and Chemical Engineering. Self-Consistent Field. In order to understand more completely the use and behavior of the self-consistent field method for molecular wavefunctions, it is proposed to treat the results of such calculations as experimental data. Simple models will be constructed, i,e., calculations which can be done exactly and explicitly in the self-consistent field approximation, and attempt to answer, for these, such questions as: When are excited states predicted by a self-consistent field calculation? When does the self-consistent field become a stable solution? Under what circumstances may one assume the ground state solution is real?

The computer will be used for self-consistent field calculations on actual small molecular systems, and the predictions made from the

model about the behavior of the solutions will be tested with reference to these results. At present a program for performing self-consistent field calculations in two-eletron systems is available and SCF programs for more complex systems are becoming readily avaiable. (Jerry Goodisman)

1424-54032 Physics. TSALLY. Theoretical cross sections for direct nuclear reactions will be computed using the Distorted Wave Born Approximation, in connection with the experimental investigation of these reactions at the Nuclear Radiation Laboratory. The program to be used, called TSALLY, has been obtained from Oak Ridge National Laboratory. (Martin Kellogg)

1425-54033 T Center for Zoonoses Research. Zoonoses Emergence - Recession Research. Zoonoes Emergence-Recession Research is the title used by several related fields of research concerned in part with the establishment of an observational network for the study of encephalitis. This problem will be primarily used for the study of relatives between sociological phenomena and epidemological observations. Because of the nature of the problem, the majority of the mathematical procedures will involve measures of association. (Robert H. Kokernot)

1426-54035 Chemistry and Chemical Engineering. X-Ray Analysis of Molecular Geometry. The problem involves the determination of the molecular geometry of complex molecules by X-ray analysis of single crystals. Calculations involved include Fourier summations and least-squares adjustment of positional and thermal atomic parameters. (G. A. Sim)

1427-54036 Philosophy. Models for Modal Logics. Truth table models using two or more values may be defined in order to test the absolute consistency, the relative consistency (with respect to negation), the undecidability of certain well formed formulae, and the independence of certain axioms from other axioms of some given system of modal logic. The computer is used to find such models, or to show that no model exists in particular cases. (C. D. Shepard)

1428-54037 T Political Science. Community Power in San Cristobal. The research problem pertains to the study of a local political system in a middle-sized Venezuelan city from an elite perspective. After isolating fifty-five community leaders by reputational techniques, they were administered a questionnaire ranging from one-half to three hours in length. Responses to the questionnaire concerning social background, mass media exposure, political awareness, political participation, authoritarian tendencies, faith in people, economic attitudes, and evaluation of community power holders constitute a large portion of the research base of the dissertation.

The 7094 will be utilized to facilitate analysis of the interview data. No programming other than that presented in the SSUPAC Manual will be utilized. The first step of analysis will involve summarization of the responses, e.g., how many individuals responded very favorable to question 22? The second step will consist of multiple correlation analysis to ascertain relationships between variables and scales, e.g., can a relationship be established between varying social background characteristics and varying degrees of political participation? Factor analysis may be employed to determine the validity of several scales. (Gary Hoskin)

1429-54038 T Chemistry and Chemical Engineering. Rotational Spectra. The computer time will be used to analyze data taken from studies of molecules in the gas phase by microwave spectroscopy. The Hamiltonian matrix is set up in a convenient basis and diagonalized by standard techniques to obtain the rotational energy levels. The rotational frequencies and intensities will also be calculated. Included in the calculations will be perturbations on the rotational energy levels due to vitration-rotation interactions, spin-rotation interaction, nuclear quadrupole interaction, Stark effect, and Zeeman effect. Molecular parameters such as bond angles and bond lengths, barriers to internal rotation, dipole moments, spin-rotation constants, quadrupole coupling constants, molecular g values, etc., will be obtained by fitting the calculated to the observed spectrum. (R. G. Lett)

1430-54039 T Civil Engineering. Elastic Wave Reflection. The object of this study is to investigate the state of stress existing in the vicinity of the free surface of a semi-infinite half space when a uniform dynamic pressure is applied with a spherical cavity located below the surface. (M.A.A. Plamondon)

1431-54041 Civil Engineering. Plates. The structural analysis of plates of varying stiffnesses in bending, buckling and in natural vibration by means of suitable finite mathematical models would be investigated. Also, folded plates would be analysed for optimal design criteria. These investigations involve a matrix formulation and solution of large sets of linear simultaneous equations by means of an electronic computer. (J.K.S. Rao)

1432-54042 Institute of Labor and Industrial Relations. University Human Relations Commission. Information available on punched cards is the result of interviews taken within the University community relating to Human Relations research projects.

The problem now is to find out what percentage of people are doing what activities. Simple percentages, weights, and number are desired. (Martin Wagner)

1433-54043 Marketing. Consumer Shopping Behavior Study. The problem is to learn the patterns for food shopping in a consumer shopping behavior study done in Champaign-Urbana. A SSUPAC program will be used on the 7094 to provide frequency counts of the data and selected cross-classifications. Data have been gathered from 261 consumer interviews. (DeBoer)

1434-54044 Agricultural Economics. Educational Status of Rural Youth. The object is to determine what are the factors accounting for differences, if there are such, between those who plan to go to college and those who do not, based on residence, sex, occupational preference, occupational aspiration, socio-economic status, personality characteristics and other conditioning influences.

Mathematical procedures to be used are:

a. Computation of simple frequencies, noncontrolled and controlled by (1) decision to go or not to go to college; (2) residence (farm or non-farm); and (3) sex.

b. Computation of (1) means of academic scores, the aptitude test, the OAS score and other variables; (2) simple and multiple correlations between these variables and (3) the 16 PF (Personality factor tests) scores.

c. Computation of "t" tests of significant differences on all variables between (1) those who plan to go to college and those who do not, (2) farm and non-farm in these categories and (3) male and female in categories (1) and (2). Variables used should include academic, aptitude OAS, 16 PF and other score means.

d. Computation of "t" tests of significant differences, based on the above categories (c(1), (2), and (3)) from all frequency tables.

(D. E. Lindstrom)

1435-54045 Mechanical Engineering. Entrance Flow. Entrance flows in vertical tubes with combined free and forced convection are investigated. The computer is used to calculate developing velocity and temperature profiles, pressure drops, and other related parameters. The program consists of two parts. The first part, the main program, calculates the coefficients in a set of difference equations. The second part is a subroutine which inverts a matrix and solves it using the Gaussian Elimination Method. (J. C. Chato)

1436-54046 Student Counseling Service. Residence Hall Survey. The Dean of Women's Office and the Student Counseling Service are conducting a survey of the residence hall counselor (G.A.) program. The problem is to determine how different people -- residents, G.A.'s, and the Administration -- preceive the role of the G.A.; how they evaluate a particular G.A.; and what they think an ideal G.A. should be. The long-range purpose of this survey is to improve the method of selecting superior residence hall counselors.

Analysis of the results will proceed using a standard statistical routine. (M. I. Appelbaum)

1437-54047 State Water Survey. Corrosion Analysis. Correlation analyses will be done for corrosion data versus various chemical factors which represent water quality. (Robert Sinclair)

1438-54048 Chemistry and Chemical Engineering. Stability Constants. The computer will be used for the calculation of stability constants of the lanthanides chelated to an organic ligand. These calculations, though simple in theory, are lengthy and the use of a computer can shorten the calculation time greatly. (J. W. Pettegrew)

1439-54049 Mining, Metallurgy and Petroleum Engineering. Moving Interfall Problem. The problem involves the study of the motion of the interfall between two fluids. It requires the solution of the Navier Stokes equation with known boundary conditions. Because these equations are nonlinear in nature, an iteration scheme was developed to convert these equations into simple algebraic equations. The iteration scheme uses eight neighboring points for computations in the Taylor's expansion. (W. D. Rose)

1440-54050 Agricultural Economics. Future Trade. The object of the study is to analyze the impact of future trading activities on fluctuations of agriculture prices and to establish relationships between future trading and short term credit activities in the agricultural sector of the U.S. economy. Time series analyses and regression analyses will be used. DCS library subroutines will be used, and no special mathematical methods (other than standard routine) will be employed. (B.J. Alkaddo)

1441-54051 General Engineering. Radon-222 Activity. Naturally occurring radon-222 is being investigated for use as a tracer material in investigations of vertical diffusivity of the atmosphere. Radium-226 contents of soils are being investigated. The emanation of radon-222 from the soil atmosphere interface is being investigated as well as the release of this material from the leaves of natural plants. Material is analyzed by an α- scintillation method and corrections for radioactive decay between collection and transfer and between transfer and counting are required as well as corrections for growth of daughters between transfer and counting. A computer program accomplishes this work. (J.E. Pearson)

1442-54052 Civil Engineering. Computer Based Management System for Contractors. This program is for the development of a complete computer based management system for the construction industry. Data systems integrated via network theory wherein the networks are dimensioned in part through the use of mathematical theories such as gueneing theory, linear programming, and inventory models are involved. Moreover, Problem Oriented Languages developed for the construction industry are included. (L. R. Shaffer)

1443-54053 T Civil Engineering. Non-linear Behavior of Folded Plates. The non-linear behavior of folded plates is to be studied by means of a framework whose members can be assigned non-linear stress-strain relations. The resulting sets of simultaneous equations will be solved by means of the IBM 7094 digital computer. (A. Karim)

1444-54054 Chemistry and Chemical Engineering. Crystal Structure of Cubenac. The crystal structure of VOPHAC has essentially been done. However, a new problem is generated from the result of this crystal structure. Some differences in bond lengths and bond angles are noted. In order to understand these differences, whether they are due to the molecular packing in the crystal or other reasons, it is decided to determine the crystal structure of a related compound - CUBENAC (copper benzoylacetonate).

Methods and calculations used in this problem are Fourier summations and least squares. (P. K. Hon)

1445-54055 Electrical Engineering. Optimization in Biological Systems. Optimization in biological systems is investigated by constructing models and computing their behaviour as a function of their parameters, and by simulation in the computer of processes for which explicit solutions are not available. Random variables will be investigated by Monte-Carlo techniques. (Dan Cohen)

1446-54056 Psychology. Information Analysis. This program reorders randomly ordered response data and converts the data from raw scores to $-P \log_2 P$ units.

1447-55001 Nuclear Engineering. Period Effect. The purpose of this study is to determine the dependence of the reactor transfer function upon the period associated with time dependent power changes. Experiments have been carried out at the Illini TRIGA and the calculations will be compared with this data. Initial calculations will use an operating reactor kinetics code based on the DCL Nordsieck Integration techniques - this code was devised by K. Hornyik. Future calculations may require further modifications, but standard numerical methods will still be utilized. (H. Hassan)

1448-55002 T Aeronautical and Astronautical Engineering. Minimum Weight Analysis. A structure consisting of r number of elements is to be designed for minimum weight based on a given probability of structural failure. The applied and failure stresses on each element are assumed to have gamma probability density functions. The areas of the elements are treated as the unknowns and r simultaneous equations in terms of the areas are to be solved. (Thomas A. Burns)

1449-55003 T Mining, Metallurgy, and Petroleum Engineering. Crystal Lattice Relationships. Diffusion less (neartersitic) phase transformations in crystalline solids involve atomic displacements which are less than the lengths of the lattice parameters: there is a change in crystal structure e.g. from cubic to tetragorial or the reverse. The WLR theory predicts the "habit" plane, orientation relationships of the two phases, and the microscopic distortions from a knowledge only of the crystal structures of the initial and final phases. The computer will be used to map results of a physically reasonable and theoretically possible range of input data. The tables will be useful as a reference and guide for the investigator and may provide insight into the consequences of the lattice constants. (T. A. Read)

1450-55004 Mechanical Engineering. Supersonic Flow Programs. The objectives of this research problem are to develop method-of-characteristics programs which consider wave coalescence and possible internal shocks. In addition, consideration will be given to including the above flow phenomena into programs dealing with the inviscid interaction between confined supersonic and subsonic streams. (A. L. Addy)

1451-55005 Education. Pilot Analysis of Attitude Scale. This research problem involves the analysis of pilot data collected during the administration of an attitude scale to approximately 450 children in grades four through nine. A refined version of this scale is one of several instruments which will be used during the academic year 1965-66 to evaluate the astronomy curriculum materials produced by the University of Illinois Elementary-School Science Project.

Programs developed at the University of Chicago and by the Office of Instructional Resources, the Department of Computer Science, and the Statistical Service Unit of the University of Illinois will be employed for purposes of item and factor analysis and to explore relationships between the test data and various independent variables (age, sex, etc.). Output from a recently developed test scoring program will be used as input for the major portion of the analysis. (Peter Shoresman)

1452-55014 Division of General Studies. Dogmatism and Learning in An Introductory Psychology Course. This study is designed to investigate the relationship between dogmatism and learning in a course in Introductory Psychology. Scores on a dogmatism scale are correlated with both precourse and postcourse knowledge of concepts, facts, and principles of psychology (course achievement). Dogmatism scores are also correlated with both precourse and postcourse scores on a test of knowledge of misconceptions in psychology. It is hypothesized that a near-zero correlation will be revealed between dogmatism and course achievement and that a positive correlation will be found between dogmatism and misconceptions in psychology. The design utilizes Pearson Product Moment Correlation and T-Test for Paired Scores. (F. Costin)

1453-55015 T Agricultural Economics. Hog Price and Income Policy. Hog price and income policy is an important sector of agricultural policy decision making.

A prerequisite to such decision making is the construction of a suitable econometric model of the directive agents in this part of the economy. Estimation of this model will be undertaken using maximum likelihood methods under various assumptions concerning the stochastic properties of the model. Both SSUPAC and IB9FES (Forecasting by Econometric Systems) programs will be used. (W. C. Ko)

1454-55016 T Institute of Research on Exceptional Children. Sensory Integration. This research seeks to verify a) that certain sensory integrative tests are testing a factor other than immediate memory or spatial-closure ability; b) that there is a one-way relationship between memory and spatial-closure ability on the one hand and sensory integration on the other; and c) that this relationship will be found in a group of children with reading problems but not in a group of non-reading-problem children. The research is attempting to clarify, amplify and add to the conceptualization of the perceptual-integrative level of psycholinguistic functioning.

The analysis will, therefore, be comprised of factor analysis, correlational and other mean comparison techniques. (Oliver Hurley)

1455-55017 T Political Science. National Political Integration in Mexico. Using a symbolic interactionist frame of reference, this study is concerned with an analysis of some factors that inhibit or facilitate the process of national political integration in Mexico. A number of hypotheses have been formulated and will be tested on data supplied by the Inter-University Consortium for Political Research. This data is based on 1295 interviews conducted in Mexico in 1959, as a part of a five nation study in political culture by Gabriel Almond and Sidney Verba.

The computer will be used to obtain correlations and cross-tabulations among variables concerning the process of national political integration in Mexico. (Byars)

1456-55018 T Civil Engineering. STRESS Translator Generator. A programming system will be developed for the IBM 7094 computer system to produce translating programs for a class of problem oriented languages similar to the STRESS language (the Structural Engineering Systems Solver). Input to the new system will be the syntax and semantics of the source language; output will be an executable translator which accepts statements in the source language and outputs linked data files.

The Floyd Production Language and Feldman's Semantic Language will be used in the implementation of the system. Portions of the implementation of these languages by the ILLIAC III Programming group will be used. (E. L. Murphree)

1457-55007 T Library Science. Costs of Library Processing. This research is an attempt to determine the cost of processing a book (e.g., preparing for use by the public) in five smaller public libraries. The processing system has been divided into sub-sections, and the library staffs have kept a daily record of time involved for each section of the process. This record contains a time, in hours and minutes: the number of total units completed in that time, plus the hourly labor rate. The computation required is the average length of time needed in each operation to complete one unit (in seconds) and the labor cost (in cents) for each unit. (Donald Hendricks)

1458-55008 Physics. Neutron Resonance Analysis. During the past three years, a family of programs and subroutines has been developed for the analysis of neutron resonance cross sections and their use in an analysis of integral experiments. At this time, it is planned to use these codes for a further investigation of neutron resonance reactions, in particular, in fissile elements. It is hoped to correlate a wide range of experimental data for total and fission cross sections and to obtain information on resonance scattering and (N,γ) reaction parameters. (F. T. Adler)

1459-55009 Agronomy. Grain Sorghum Breeding. The purpose of this problem deals with the improvement of grain sorghum varieties and hybrids through breeding programs such as recurrent selection. Data on several characters will be obtained and analyzed on the computer using available analysis of variance programs. (Hadley)

1460-55010 Agricultural Economics. Farm Size Economies. A comparison of the economy of production on farms of different sizes will be made. Two types of farms will be considered: corn farms and hog farms. Labor available will vary from one to six men. Different complements of machinery and equipment will also be considered.

The linear programming method will be used to estimate the minimum cost methods of production for each situation. (R.N. VanArsdall)

1461-55011 Department of Computer Science. Semiconductor Statistics. The measurements of new semiconductors will be punched on paper tape.

ILLIAC II will be used for converting this tape to punched cards for permanent storage, for generating statistics about the semiconductors, and for drawing graphs used in acceptance level decisions.

At future dates the semiconductors will be retested. Both the new and the old information will be used to determine drift of semiconductor parameters with age. (J.J. Smith)

1462-55013 T Agricultural Engineering. Home Heating Study. The nature of the problem is as follows: to develop generalizations regarding the attitudes, opinions, and knowledge level of consumers relative to heating their homes with electricity in Illinois in order to improve the effectiveness of marketing strategy. Computer will be used to compute frequency distributions of about 140 variables and accomplish cross-tabulations of selected variables. (J. K. Clemens)

1463-55019 Marketing. Class Marketing Research Project. This is a project that is done in cooperation with the Illini Union and Marketing Department for the purpose of providing educational research experience for students in Marketing Research 321. (H. Wales)

1464-55020 Nuclear Engineering. Fission Electric Cell. The fission electric cell is a device for the direct conversion of nuclear to electrical energy. The problems associated with this device which will be studied on the computer are: fission fragment range-energy-charge models, and cell efficiencies. The calculations involve numerical evaluation of integrals and standard techniques will be employed. Some operating codes developed earlier will be extended to consider other models and geometries. (G.H. Miley)

1465-55021 T Physical Education for Men. Causal Analysis of the Total Peripheral Resistance. Problem: What is the total peripheral resistance (TPR) of adult men at basal state, and what are the factors that take part in it? Method: Data had been collected from heartographs of 154 adult men who participated in the physical fitness program at the University of Illinois in the last ten years.

The TPR will be computed from the given cardiovascular variables in three different ways. The purpose of this study is 1) to analyze the relationship between the three methods, and 2) to employ two methods of causal analysis when using the TPR as the main criterion, and other physical and cardiovascular variables as the independent ones.

In order to get the answer to this study the Statistical Service Disk System II Multiple Regression Analysis Program will be used. (Asher Farhi)

1466-55022 T Civil Engineering. Rectangular Notch. The stress distribution in the vicinity of a rectangular notch cut in a continuous medium which has a horizontal surface and rests on a rigid base will be investigated for specified stress conditions along the boundaries of the notch. The dimensions of the notch, the thickness of the continuous medium, and the boundary stresses will be varied. A numerical solution for the elastic case will be made by use of the airy stress function and finite difference equations. The computer will generate the coefficients of the difference equations and solve the resulting set of simultaneous equations by the Gauss-Seidel iteration method. A suitable model will be used for a plastic solution. (Elmo Dibiagio)

1467-55023 T Industrial Administration. Analysis of Leadership Effectiveness. A statistical analysis requires 1) correlating leadership style with work group effectiveness; and 2) intercorrelating a large number of work group characteristics. (J. G. Hunt)

1468-55024 T Physics. Cubic Equation Stability. We are using the highly accurate Illiac II for studying the stability of solutions to the cubic equation

$$\ddot{X} + p(t)\ X^3 = 0$$

where p(t) is a square wave (in time) in our present investigation. This has integrals in the form of elliptic functions, and so we can calculate its solutions very accurately from closed algebraic forms (to the accuracy of our elliptic function tables - some 10 to 12 places). We locate periodic solutions in the phase $(X, \dot{X})$ plane and then look at the nature of the motion in the vicinity of these solutions over long periods of time. We also study the nature of the mapping (over a single total period) of the region to determine stability. (C. A. Wagner)

1469-55025 Chemistry and Chemical Engineering. X-Ray Structure Analysis. With the aduent of automatic X-ray Diffractiometers, it is becoming simpler to collect accurate data for direct x-ray analysis in a very short time. The main object of this problem number is to enable detailed refinements of some of the structures studied on the Philips-Datex Diffractiometer to be carried out. The nature of these structures will be quite diverse, but it is hoped that the extension in accuracy of the measured data will provide useful chemical information. (I. C. Paul)

1470-55026 T Psychology. Study of Ambivalence. This will be a study in attitude scaling. An attempt to distinguish ambivalence from indifference using 7 point "good-bad" and 4 point "good-neutral" and "bad-neutral" scales. Various criteria and predictors will be used and a considerable number of correlations will be done on the various measures. Additionally, individual differences will be examined in a factor-analytic procedure.

The study will use Fishbeins model $A = \sum a_i B_i$ and will both give the subject beliefs (B_i) and elicit the subject's own beliefs. These results will be compared also. (K. J. Kaplan)

1471-55027 Chemistry and Chemical Engineering. Nuclear Magnetic Resonance Studies. Some nuclear magnetic resonance studies require 1) analysis of complex N.M.R. spectra using programs NMRIT and NMREN which are already available, and 2) studies of fast exchange phenomena in N.M.R. spectra.

Programs have already been developed for doing this. The rates of exchange are determined simply by comparing experimental spectra with those calculated, assuming different exchange rates. (J. A. Ladd)

1472-55028 Natural History Survey. Raccoon Physiology. Multiple regression to determine mean weights of various organs in wild healthy raccoons (procyon lotoc) according to age, sex, and month are to be performed. The effect of each organ weight, if any, on all other organ weights, and the effect of body size, if any, on the mean weight of each organ will be computed. This will provide "base line" information for disease and physiological studies in wild and captive raccoons. (Glen C. Sanderson)

1473-55029 T Political Science. Social Backgrounds and Voting Behavior. The research problem is to analyze the relationships between social background characteristics and voting behavior of members of the Eighty-sixth House of Representatives. Social background characteristics include age, education, career, and geographical mobility. Voting behavior is measured by percentage-support scores on seven categories of roll calls. Each background (independent) variable is related to each voting (dependent) variable by chi-square analysis. Analysis is done for the entire House membership and also for each party's members. In addition, analysis is done for each independent variable while holding other independent variables constant. (Peter J. Ostergren)

1474-55030 Electrical Engineering. The Electron Density in the Ionosphere. $N = N(h_2t)$, the ion density in the ionosphere, can be described by the nonlinear partial differential equation

$$\frac{\partial N}{\partial t} = A(h_2t) : \frac{\partial^2 N}{\partial h^2} + B(h_2t) \cdot \frac{\partial N}{\partial h} + \left[C(h_2t) + D(h_2t_2N)\right] \cdot N + Q(h_2t)$$

with the boundary conditions

$$N = 0 \qquad \text{at } h = 0$$

$$\frac{\partial N}{\partial h} + \frac{1}{2H(t)} \cdot N = g(t) \qquad \text{at } h = 1$$

and some specified initial conditions $N(h_2O)$.

Two finite difference techniques will be used to solve the above equation: the backwards difference method (involving two t-levels) for starting the solution or changing the spacing along the t-axis, and a central difference method (three t-levels) for the main part of computation. In either case the resulting algebraic problem is a tridiagonal system of linear equations. A special version of Gaussian elimination is used to solve such a system. (K. C. Yeh)

1475-55031 Physics. M-Center Absorption. In plotting the absorption strength of the M-center versus log $(E-E_o)^2$ (where E is the energy of the light for that absorption and E_o is the energy of the light for maximum absorption) the slope of the plot can be matched by the configuration coordinate diagram theory if appropriate values are taken for the spring constants in the ground and excited states. The computer is to be used to calculate the slopes arising from various spring constant ratios to find a match with the experimental results. (George A. Russell)

1476-55032 T Political Science. Voting Study. This project includes an analysis of the possibility of predictive equations of presidential elections, using counties and metropolitan areas as voting units, and an analysis of the residuals. By multiple regression the predictive values of such factors as Catholicism, ethnicity, income, industrialism, and previous voting patterns are to be determined. (Robert Erikson)

1477-55033 T Chemistry and Chemical Engineering. One Center Hartree-Fock Calculations for Molecules. The Hartree-Fock Self-Consistent Field method is used to examine various molecules. One center molecular orbitals are expanded in a series of spherical harmonics up to the third order. The potential field of the off-center nucleus is correspondingly expanded up to sixth order. Using this scheme, a set of coupled integro-differential equations will be obtained. An iterative procedure is used to calculate an approximate solution. This will involve numerical integration of the 2nd order linear differential equations (with two boundary conditions). (Jane Keefer)

1478-55035 Agronomy. Course and Teacher Rating Forms Summary. The course and teacher rating forms are a summary of the student's opinion of a course, the teacher instructing the course, of the textbook or references used in the course, and of the laboratory instructor (if applicable) for the course.

As of this date, the rating forms will be distributed to all courses taught in the Agronomy Department. The summary of these forms will enable the instructor to find out the weaknesses of a course he is teaching, and of himself as the instructor of the course.

A program has been developed to provide a summary of the forms for a given course, a number of courses, a given laboratory section, and a number of laboratory sections. (Seif)

1479-55036 T Aeronautical and Astronautical Engineering. Matrix Algebra Computer Language. The purpose of this research is to develop a Matrix Algebra Computer Language as a tool to be used to obtain numerical answers to problems that are presented in matrix algebra notation.

The Matrix Algebra Computer Language will be a computer programming system (compiler) to process extensive matrix operations from simple, symbolic input. The programming system will perform all the matrix operations called for, and will handle all the storage and housekeeping requirements of the computer.

Operations in the language are such that most problems in the fields of aeroelasticity, dynamics, strength analysis, vibrations, stability, and statistics that can be formulated in matrix algebra can be solved. Provisions will be incorporated to handle large matrices with zero suppression, as well as complex matrices and double precision matrices. (Mel Haas)

1480-55037 T Educational Psychology. Occupational Preferences of High School Sophomores. The problem concerns studying the level and category of occupational preferences of high school sophomores as functions of sex, race, socioeconomic status, intelligence, and aspects of self-evaluation. Distributions of occupational preference classification (by level and by group) for each combination of categories of sex, race, socioeconomic status, and I.Q. (chi-square values) are to be determined.

The results relate occupational factors and occupational preferences, and occupational expectations to independent variables. Multiple regression will be used in this comparison. (Ronald Boguski)

1481-55038 T Physics. Hot Electron Effect in KBr. The problem requires curve fitting of hot electron data of KBr to theoretical curves. Standard library routines are involved only. (Mikkor)

1482-55039 Mechanical Engineering. Shaft Vibration. The Myklestad-Prohl method will be applied to obtain bending natural frequencies of a shaft with a gear on each end. The shaft has two simple supports with the gears overhanging each end.

The effects of changes in mass and shaft stiffness on the natural frequencies of the system will be studied. (R. W. Adkins)

1483-55040 T Physics. Analysis of Diffusion Data for Cl^{36} in KCl. In Part I the LSQ2 program will be used for a least squares fit of a polynomial to experimental log (diffusion coefficient) versus $(\frac{1}{t})$ data, in the form

$$\log_{10} D = a_o + a_1 (\tfrac{1}{t}) + a_2 (\tfrac{1}{t})^2$$

D = Diffusion coefficient for Cl^{36} in KCl, in $cm^2/sec.$, and
T = absolute temperature in ^oK.

Part II requires a least squares analysis for data to fit an equation of the form

$$D = D_1 e^{-w/rt} + D_2 e^{-Q/rt}, \text{ where}$$

k = Boltzmann's Constant and D_1, D_2, W, Q are parameters to be determined. (R. G. Fuller)

1484-55041 T Agronomy. Available Phosphorus in Illinois Soils. The problem involves analyzing dilute acid fluoride extracts of soils for phosphorus, aluminum, iron, calcium, magnesium, manganese, and silicon. Relationships between various ion species will be studied, particularly with reference to phosphorus extracted. Different extractants are to be used and an attempt will be made to understand the nature of plant-available phosphorus and related cations. Available computer programs will be used to perform correlation and regression analyses on the data. (Kurtz)

1485-55042 Dairy Science. Dairy Cattle Management Research. The object of the research is to determine the advantages and limitations of certain management systems and practices employed on dairy farms. The computer can be used to perform many of the routine additions, subtractions,

multiplications, and divisions necessary to prepare the data into the proper condition for statistical treatment. The statistical analyses to be used will include least squares analysis of variance and analysis of covariance for equal and unequal subclass numbers; also simple and multiple correlation and regression. (Sidney L. Spahr)

1486-55043 Political Science. Illinois Legislative Assembly Nomination Strategies. The study focuses on the strategies used by the two major political parties to designate the number of candidates they nominate to the Illinois House of Representatives from 1902 to 1954. The special requirements of the cumulative voting system require specific strategy decisions by the party leadership.

Two alternative explanations have been offered for the number of candidates actually nominated by the political parties. One explanation emphasizes the mathematics and logic of game theory and posits that each political party organization calculates and nominates, either rationally or on a trial and error basis, the largest number of successful candidates possible, given the alternative strategies available to the opposition party and the typical percentage division of the vote between the two parties in the legislative district, i.e., the "minimax" solution of game theory, highest minimum and lowest maximum gain. The alternative explanation emphasizes the desire of incumbent legislators to protect themselves against defeat at the expense of possible party gains. In this way, the frequent failure of the minority party to nominate two candidates in a closely competitive district is accounted for.

Both explanations must allow for numerous exceptions and they imply two quite different relationships between the political party organizations and incumbent legislators, and therefore, strongly contrasting assessments of Illinois politics. The design of the study being proposed would attempt to assess the relative and combined importance of these two explanations, one based on security for the party and the other based on security for the incumbents.

The computer analysis will consist of correlations and cross-tabulations involving measures of incumbent tenure, voting pattern stability, and deviations from minimax solutions. (Judson L. James)

1487-65001 Electrical Engineering. Self-Organization. The aim is to study algorithms by which a system can improve its run performance of a task as a result of experience. A system and a task environment will be simulated in the program. Self-improvement results partly from the adjustment of parameters, but the system also undergoes changes which are more readily describable as alterations in its structure than as parameter adjustments. Parallel computation in a set of essentially similar units will be simulated, with means for insertion and removal of units according to prearranged criteria. The program will allow experimental changes in these criteria and other features of the system. The effects of these on system performance will be examined. (Alex Andrew)

1488-56002 T Physical Education for Men. Statistical Analysis of Effects of PEM 100. Statistical analysis of a ten item motor fitness test will find the product moment correlation between items. (Beach)

1489-56003 T Agricultural Economics. Demand for Housing for Single Persons. The purpose of this study is to investigate the cross-sectional demand for housing of urban, single, fully-employed, non-institutional male and female individuals in the United States, to estimate the parameters of a demand function for housing and to estimate the income elasticities for housing for this segment of the population. A lesser, but important, purpose is to investigate the socio-economic characteristics of these individuals as a basis for interpreting their demand for housing. Computer analysis will include frequency counts by selected variables and multiple regression analysis. Coefficients of multiple and partial determination will be determined to estimate the extent of relationship between the variables and will include the standard deviation of regression which will give an estimate of the unexplained variance. Beta-coefficients may also be determined to estimate the relative importance of the variables. (E. D. White)

1490-56004 T Agricultural Economics. Market Efficiency Study. The research problem is an appraisal of the efficiency of a retail fertilizer market in a portion of Illinois. In this problem an attempt will be made

to specify the variables which contribute to or cause an efficient or inefficient market; also the relationship (if any) between market structure, conduct, and performance and the underlying variables will be examined. Secondary objectives are to provide the implications of the results to buyers and sellers of fertilizer in light of varying degrees of market efficiency.

The models used will be multiple regression and correlation employing both quantitative and zero-one variables and variance and covariance analysis. The computer may be used to solve these models. (J. Schaub)

1491-56005 Civil Engineering. 1965 Geodesy and Photogrammetry Institute. Students enrolled in the Geodesy and Photogrammetry Institute are required to solve several problems pertaining to the positioning of points in space, in particular the adjustment of triangulation, trilateration, traverse and level networks. The method of least squares is used considerably in the adjustment procedures and the statistical properties of the least squares estimates are also investigated. Matrix methods are employed throughout several of the problems. The students are also required to apply a number of coordinate transformation procedures to several problems in analytical photogrammetry. The digital computer is of great assistance in handling the linear computations and statistical operations involved in these problems. (W. H. Eldridge)

1492-56006 T Chemical and Chemistry Engineering. Linear Least-Squares Fitting for Analysis of Gamma-Ray Spectra. The problem is to determine the ratio of reaction cross-sections for the (gamma, 2 neutron) and the (gamma, proton neutron) reactions in various nuclei. The present computer program will decompose a composite gamma-ray spectrum into its basic components. The relative intensities of the components will be fitted and adjusted by means of linear least-squares fitting. By obtaining the ratio of intensities of the components it is then possible to obtain the ratio of various nuclei produced and thus the ratio of the reaction cross-sections. (John Hummel)

1493-56007 T Economics. Best Consumption Functions. Since the absolute income theory of consumer behavior was first articulated in 1936, many hypotheses have been developed in the attempt to explain movements in this important component of aggregate demand. Researchers have been faced with the constant problem of empirically verifying theories in this area. The problem is one of finding some statistical method which will allow differentiation between alternative aggregate theories of consumer behavior. Ordinary single-equation least squares and associated methods, applied to various aggregate consumption equations arising from theory, have failed to provide an adequate basis for differentiation. By testing each of these equations within the context of an econometric model and applying simultaneous equations estimating techniques to these alternative models, it is hoped that the results will give a basis for choosing a single "best" consumption function. The computer will be used to make the parameter estimates and calculate the test statistics necessary to test this idea. The simultaneous equation estimation program to be used was developed by the Statistical Services Research Unit of the University of Illinois. (Warren T. Strong)

1494-56008 T Labor and Industrial Relations. In-Basket Executive Selection. This study is an attempt to use the scores of an executive In-Basket test to discover and define executive style and its relationships to executive success. A 39 item In-Basket test was administered to 52 executives of a nationwide corporation. These tests were then scored on 48 different categories and 9 criteria of success were gathered on each man.

It is hoped that through a correlational analysis of the category scores and the criteria information, it will be possible to statistically identify certain categories which are significantly related to either to successful or the unsuccessful executives in the sample, and to approach a tentative definition of either successful or unsuccessful executive style. (Lauren E. Miller)

1495-56010 T Mining, Metallurgy, and Petroleum Engineering. Internal Friction Studies I. Calculations are to be performed using a random number generator to accumulate pertinent data on the distribution of dislocation loop lengths occurring in high purity metals. These data will subsequently be used for the numerical calculation of predicted strain amplitude dependence of internal friction in these materials arising from dislocation motion. Temperature dependence may also be investigated. Experimental data may be fitted to these predicted behaviors, in order to determine certain fundamental properties of the materials being studied. (Dale Trott)

1496-56011 T Civil Engineering. Cylindrical Shells With Holes. The object of the problem is to solve for the displacements, moments and forces in an elastic cylindrical shell containing rectangular openings with stiffened edges.

The shell surface is replaced approximately by a physical model of rigid bars and deformable joints in a rectangular array. Strain displacement relations are written in terms of the longitudinal, transverse and radial displacements of the node points. Using the principle of virtual work, a linear algebraic equilibrium equation, written in terms of the unknown displacements of the node points is developed in the computer for each node point. After developing the system of equilibrium equations, the computer is used to solve these equations for the displacements of the node points, using the Gauss elimination procedure. Moments and forces, written in terms of the displacement, are then calculated by the computer. (Richard Pinckert)

1497-56012 Mining, Metallurgy, and Petroleum Engineering. Multiple Decay Analysis. This problem involves the analysis of a set of experimentally determined data describing the anelastic relaxation of a metallic specimen. This relaxation is, in general, the sum of n discreet relaxation processes, described by the equation

$$\phi(t_k) = \sum_{i=1}^{n} A_i \exp(-B_i t_k)$$

ϕ is the normalized anelastic strain at time t_k, A_i is the strength of the i^{th} relaxation relative to the total and B_i a constant describing the relaxation time of the i^{th} process. The FØRTRAN language program used in this study allows the calculation of relaxation strengths and relaxation times of all component relaxations by use of an iterative least squares fit to the experimental data, giving not only the best values of these quantities but also, if desired, a best estimate of the errors, and an evaluation of the goodness of fit. (Dr. Mosher)

1498-56013 T Education. Science Methods Course Evaluation. The purposes of this study were to (1) provide accurate descriptive information about the practices in science methods courses as they are taught in the United States, (2) to attempt to determine through this knowledge of their practices, by comparison with a model course, areas of strength and weaknesses, and (3) to identify possible reasons for the existence of these areas of strength and weakness.

The method used to gather data was the survey technique which utilized twin Likert scales of conviction and practice opinion ratings for 64 descriptive statements. The computer is to be used to determine the frequency of ratings and the correlation association between conviction and practice statements. (Jack A. Reed)

1499-56014 T Veterinary Pathology and Hygiene. Effects of Co^{60} Irradiation on Blood Constituents and Hematopoietic Organs in Calves. In a study of incidence, pathology and transmission of bovine lymphatic leukemia, a comparison is being made of calves irradiated with C_o^{60} to determine dosage to be used in transmission of affected tissues and filtrates. The present work compares hematologic and hematopoietic differences in calves receiving different Co^{60} irradiation doses. (R. E. Olsen)

1500-56015 T Forestry. Growth of Pines on Sandy Upland in Western Illinois. The study is concerned with soil/site relationships of Red pine, White pine and jack pine on sandy upland and river terrace

soils in western Illinois. Soil factors including pH, organic matter, particle distribution, and depth of horizons will be related to the annual height increment in growth of the trees. The computer will be used to perform multiple linear regression analyses on the data. Programs for this purpose are already available. (Boggess)

1501-56016 Physics. Development of Bubble-Chamber Analysis Programs. Work currently in progress directed toward producing a programming system for analyzing large quantities of data from high energy physics bubble chamber experiments is to be expanded. Such a system must identify and extract the essential features of the data and present them in a manner facilitating comparison with physical theory. (Ascoli)

1502-56017 Astronomy. Expansion and Ionization Models of Gaseous Nebulae. The major part of the problem is to compute the level of ionization in gaseous nebulae as a function of distance from the central star. Observations of radial velocities of nebulae in the light of different ions will then be combined with the above to produce expansion models of the nebulae. The ionization model necessitates knowing the distribution of energy radiated by the central star which can be found from the intensities of nebular spectral lines.

Plates of the nebular spectra will be run on a microphotometer which can digitize the position and photographic density of spectrum lines. These data will be reduced to yield wavelengths and intensities.

The theoretical models involve primarily the numerical integration over the ultraviolet region of the stellar spectrum to obtain the total amount of ionizing radiation at various points in the nebula for ions of different ionization potential taking into account the dilution of the radiation field by the nebula itself. (James Kaler)

1503-56018 Chemistry and Chemical Engineering. Barriers to Rotation. To calculate and explain barriers to internal rotation and other steric problems of molecular structure, it is proposed to calculate the forces exerted on the nuclei by the electronic charge distribution. The integrals involving the force operator can be reduced to double sums of one-dimensional integrals, which may be evaluated numerically. (Jerry Goodisman)

1504-56019 Institute of Communications Research. Productivity of Ph.D.'s by Sex. The objective of the study is to measure the relative productivity of women who have received their Ph.D.'s in five major divisions (natural sciences, biological sciences, humanities, social sciences, and education) in the past six years. The data will describe systematically the woman Ph.D.'s professional contributions (publications, research, teaching, consulting, etc.) and her personal and social characteristics and her life style. Addresses of recent woman Ph.D.'s (and a comparable male group) were obtained from Index to American Doctoral Dissertations and from alumni foundations. Questionnaires were sent to some 6,000 respondents located in over 150 Universities throughout the country. As of this date approximately 40% of the questionnaires have been returned.

The analysis will consist primarily of cross tabulations of some three to six independent variables such as, field, year of degree, quality of university from which degree was received, marital and children status, by a variety of independent variables such as occupational history, number of publications, etc.

Standard library routines from SSUPAC should be adequate for the necessary frequency distributions and chi-square analyses. (Rita Simon)

1505-56020 T Civil Engineering. Finite Element Approach to the Analysis of Skewed Girder Bridges. The problem consists of developing a stiffness matrix method of analysis for a skewed plate with eccentric girder stiffeners. In this method, the plate and stiffeners are divided into finite elements, and for each element a stiffness matrix is developed. The individual stiffness matrices are summed together to form a single stiffness matrix for the structure by satisfying the equations of equilibrium at the node points. Ultimately the problem involves the solution of several hundred simultaneous equations to which a Gauss elimination procedure for banded equations (developed by Prof. J. Melin) will be used.

The computer will be employed to do much of the matrix algebra necessary in establishing the stiffness matrices for the individual elements, to generate the large number of simultaneous equations, and then solve them. Using the solution to the equations, the computer will then perform the necessary matrix algebra to establish the results sought (i.e., the forces acting in the structure).

When a working program is established, the behavior of the skewed bridge will be studied as a function of the various parameters involved, such as skew angle, girder stiffness, plate stiffness, boundary conditions, and variations in the assumptions upon which the problem was originally set-up. The computer will, of course, make possible the study of a wide range of parameters. (Wm. C. Gustafson)

1506-56021 T Geology. Grain Size Analysis. Information on the true particle size distribution of any sediment at its time of deposition is of fundamental importance to an understanding of its origin.

Approximately two hundred samples of fine-grained surficial bottom sediments from southwestern Lake Michigan were analyzed by the hydrometer technique of particle size analysis. The hydrometer analysis is based on the settling velocity of small particles in water, as computed on the basis of Stoke's Law. This method allows one to measure the change in density of a sediment suspension with time, as successively smaller and smaller size particles settle out. The data are collected by placing a hydrometer calibrated to read grams of sediment per liter in the suspension at various intervals of time after initial introduction of the sample. The other variables recorded are: initial amount of sediment suspended in the water; time interval (in minutes) between hydrometer readings; water temperature at each hydrometer reading.

Until recently, the calculation of the particle size distribution for any given sample, involved long, tedious manipulations of the above data. A computer program developed by Dr. Tom Liu of the University of Illinois Civil Engineering Department now enables the sedimentologist to rapidly calculate the diameter (in millimeters) of any particle remaining in suspension after a known lapsed time interval, and also the total percentage of that particular size particle in the sample. This allows one to eventually determine the complete range of the grain size distribution in that sample. (Paul Josephson)

1507-56022 T Recreation. Minneapolis Census Tracts. This research problem is an analysis of quantitative data on leisure activities. The data was collected from teenage and adult residents of selected census tracts which vary according to ecological and demographic variables. Summary statistics and statistics testing differences between tracts in the quantitative uses of leisure by residents of the respective tracts will be included in the computer output. (Thomas Goodale)

1508-56023 T Civil Engineering. Analysis of Suspension Bridges Subjected to Heavy Static Loading. A numerical scheme of successive approximations will be used to analyze suspension bridges which are subjected to heavy static loading. The assumptions of the so-called "deflection theory" will be employed, but the bridge will be treated as a system of discrete structural elements, as opposed to the normal assumptions of a continuous girder and cable. This approach leads to a system of nonlinear algebraic equations that must be solved simultaneously. A generalized Newton-Raphson Method will be employed to solve these equations by an incremental procedure. The method of analysis will be designed to handle the many different arrangements in structural detail that are commonly used in suspension bridge design. The effects on the accuracy of the results caused by varying the main parameters will also be studied.

This study can be pursued only through the use of a computer because of the large number of equations involved and the nonlinear nature of the problem, which necessitates the use of a successive approximation approach. (Harry H. West)

1509-56024 Civil Engineering. Curvature and Deflection Values For Prestressed and Reinforced Concrete Beams. The problem is to predict the bending elements, rotation, and deflection of prestressed and ordinary reinforced concrete beams up to and beyond the maximum moment-point. This will involve modifying the stress-strain curve for concrete beyond the strain of 0.4%, where the curve exhibits a decending trend. It is intended to vary the shape of this curve by a trial and error procedure until computer values of bending moment, rotation and deflection closely fit values from actual tests. (Thomas Koso)

1510-56025 T Psychology. Cognitive and Reinforcement Conditions. This research problem is to determine the nature of the effects of five different counseling procedures (primarily operant conditioning of positive self-references vs. a cognitive restructuring approach). There were 21 subjects under each treatment and seven interviewers. SSUPAC will be the program system used to run analysis of variance and multiple comparisons tests in a 5 (treatment) by 7 (interviewer) design using pretest and posttest difference scores and interview ratings as the dependent measures. Several variable interrelationships will be studied in addition using correlational techniques. (Juanita Baker)

1511-56026 Natural History Survey. Home Ranges of White-tailed Deer. The computer will be used to aid in tracing the movement patterns and home ranges of Consanguineous white-tailed deer. Analysis of data will be by the method of least squares. (G. G. Montgomery)

1512-56029 Civil Engineering. Lateral Loads in Multistory Structures. The computer is to be used for an accurate analysis of multistory reinforced concrete buildings subjected to lateral loads. The lateral forces are wind, and loads resulting from earthquake. More than thirty typical structures are to be analyzed with various column-to-girder stiffness ratio, number of stories, and number of bays. FORTRAN and STRESS are to be used for this purpose. This work constitutes a part of research on the evaluation of the present methods of analysis used in design of multistory buildings. (N. Khachaturian)

1513-56032 Civil Engineering. Frequencies of Laminated Shells. In a study of the vibration and wave propagation of heterogeneous elastic cylindrical shell, three approximate theories based on different assumptions on the deformation of shells are proposed. Frequency curves (frequency vs wave length) are obtained from these approximate theories for a specified infinite two-layer shell in harmonic motion. In order to study the range of applicability of these approximate theories, the frequencies of the shell from the exact elasticity theory will be obtained for comparison. In the exact elasticity solution, a generalized Hozler method has been adopted as the numerical method to compute the exact frequencies. (P. C. Yang)

1514-56033 Agricultural Economics. Economy of Hog Production. The research problem is to estimate production requirements, costs and returns for alternative hog production systems. The computer will be used to make cross-classification and regression analyses of farm performance data. From these relationships generated, the computer will be used to make linear programming analyses to predict optimum production systems. (R. A. Hinton)

1515-56034 Veterinary Pathology and Hygiene. Micrometeorology. An ecological study on the effect of the micro-environment on the development and survival of various nematodes parasitic in ruminants has been initiated. The data collected will be divided into two main categories: (1) the collection and tabulation of all meterorologic measurements made at the experimental plots in Urbana. These include precipitation, temperature at various levels and under various conditions of plant cover, relative humidity, wind, solar radiation, dew duration, evaporation, and soil mositure. Potential evapotranspiration and available soil moisture storage will also be calculated with empirical formulae; (2) the collection of all data on the recovery of parasites from the experimental plots.

The computer will be used to calculate and tabulate all data from both categories and to analyze any correlations relative to the effect of the micro-environment upon the development and survival of various stages of the particular parasites being investigated. (F. L. Andersen)

1516-56035 Psychology. S-R Inventories of Traits. An important and recurrent issue in personality theory is whether the major source of variance in behavior derives from the person or from the situation. Personologists have assumed that individual differences constitute the major source of behavioral variation while social psychologists have emphasized the primacy of situational factors. An analysis of the S-R Inventory of Anxiousness data suggests that the debate over the relative importance of individual differences and of situations is largely a pseudo-issue. Variance components derived from the mean squares of three

way classification analyses of variance indicate the subjects (Ss) account for about 5% of the total variation (sum of the variance components), situations account for about 5 - 12% of the variance, modes of response for about one quarter to one-third of the variance and that nearly a third of the variance comes from the three simple interacts (Ss x situations, Ss x Modes of Response, Situations x M-R). These proportions are highly stable across samples of subjects where the same form of the inventory has been used.

The aims of the program are: 1) to continue the development of the inventory of anxiousness to permit more accurate description of individuals in terms of appropriate categories of responses to appropriate categories of situations. The computer will be used to factor analyze the subjects' modes of response and situational scores. 2) To ascertain the generality of the findings from previous studies across various modifications of the samplings of subjects, across various modifications of the samplings of situations and of modes of responses. Three way analyses of variance will be computed and variance components will be derived from mean squares. 3) To explore the validity of inventory reports of various autonomic responses in terms of actual autonomic responses to various kinds of situations. It may be feasible to "digitize" and tape record the autonomic responses (derived in analogue form from a polygraph) so that they can later be analyzed on the electronic computer of the Coordinated Science Laboratory at the University. It will be necessary to write a computer program for this purpose. 4) To determine if the principles of personality description discovered with the various S-R inventories of anxiousness will hold with the trait of anger. The S-R anger situational and mode of response scales will be factor analyzed. Three way analyses of variance will be computed on the raw data and variance components will be derived from the mean squares. This will enable us to determine the relative contribution of situational, subject, mode of response, and interactions to the total behavioral variation. (Norman S. Endler)

1517-56036 T Mechanical Engineering. Air Flow, Combustion and Heat Transfer Studies of a Cupola. This problem involves a study of the dynamics of air flow, combustion, and heat transfer within a cupola furnace. Data from a scale cupola will be correlated with predictions from water table studies and mathematical models. The computer will be used in the scaling of the experimental cupola from data on industrial size cupolas. (Tom Degenhart)

1518-56037 Chemistry and Chemical Engineering. NMR Analysis of Multiple Spin Systems. The calculation of chemical shifts and coupling constants from the observed high resolution nuclear magnetic resonance spectra of molecules containing as many as 8 spins will be performed, to obtain a best set of trial parameters for the spin system considered. (J. Jonas)

1519-56038 English. Study of High School English Programs. This project ("A Study of High School English Programs Which Do and Do Not Prepare Outstanding Students in English") is an attempt to identify unique characteristics of outstanding school programs. Through visitation, interviews, and questionnaires, data have been gathered on 168 high schools in 46 different states. By comparing measures of central tendency and dispersion with the use of a computer, certain critical variables may be identified. The data collected are so extensive and detailed that they cannot be analyzed expeditiously except by use of the computer. Among the data to be analyzed will be the relationship in these schools of the preparation and inservice education of teachers, the financing of the schools, teaching conditions and class size, school programming, and related matters. (James R. Squire)

1520-56039 University High School. Higher Intellectual Processes of Culturally Deprived Children. This study is concerned with an analysis of certain of the higher intellectual processes manifested by culturally deprived children of high potential. The results of this study will help psychologists, educators, and others develop educational programs that are more appropriate to the needs of these children.

One hundred seventeen measures of intellectual functioning, academic achievement, socioeconomic status and intellectual environment have been obtained on 200 selected children. Scores of the total group and various subgroups of children will be evaluated statistically to determine the strengths and weaknesses of the subjects. Also, relationships, factors, and other significant aspects will be studied using a variety of techniques including correlation, factor analysis, chi square, and possibly analysis of variance and multiple discriminant analysis, depending upon the limitations imposed upon the analyses by the various measures.

The processing of data will be conducted in two phases. Initially the data will be evaluated to determine basic qualities of the obtained scores including such information as means, distributions, etc. After evaluation of the initial results, an appropriate strategy will be developed to obtain most economically the final results.

This project is sponsored by the Program for the Gifted of the State of Illinois. (W. M. Rogge)

1521-56040 Law. Teacher Proficiency Analysis. The statistical distributions of various factors relating to teacher training, aptitude and proficiency are to be determined in order to discover the underlying factors that contribute to effective teacher training. (Ralph Reisner)

1522-56041 Dairy Science. The Utilization of Feed Nutrients by Dairy Cattle. The utilization of nutrients for growth and lactation influence the efficiency of animal production, and various sources of nutrients are being evaluated to obtain data which can be used as a basis for determining efficient production procedures. Observations are made of feed intakes, weight gains, heart girth gains, wither height gains, milk production, fat tests, and input-output ratios in experimental trials. These data must be summarized, evaluated, and tested for statistical significance. The computer is to be used to reduce the time needed to process data and to increase the amount of data processed. (K. E. Harshbarger)

1523-56042 T Zoology. Bio-Energetics of Red Polls. The energy cost of living changes at different temperatures in a more-or-less linear fashion. The excretory energy subtracted from the gross energy intake of an animal will give a value of metabolized energy utilized under any environmental condition. In the present experiment, when a bird held a constant bodyweight during a test period, this latter value was termed "existence energy". This is the energy required for just existing, under caged conditions, and with the birds carrying out their normal activities (feeding, preening, etc.).

Since these values all regress on temperature, it is desirable to determine the regression lines, which can then be compared with those for other species subjected to similar conditions, and used to determine how different species react to and exist under different conditions.

Lines drawn by eye through the plotted points often appear to have not only linear, but also quadratic and cubic components, and since calculating these by hand is both tedious and gives considerable chance for error, it is felt that they are best calculated by the computer. (William S. Brooks)

1524-56043 Division of General Studies LAS. Faculty Attitudes Toward Teaching Evaluation. This study measures faculty attitudes toward teaching and research, rewards for teaching, and the evaluation of teaching by students and administrative supervisors. The computer will be used to report correlations between attitudes on related concepts and between groups of faculty members classified by age, college, years of teaching at Illinois, etc. (Halbert Gulley)

1525-56044 T Labor and Industrial Relations. Job Satisfaction by Organizational Level. Two hundred managers from the level of president to foreman have been questioned about their job satisfaction with pay, people, promotions, supervision, and the actual work done by means of the Job Descriptive Index. In addition, data has been gathered on certain demographic variables and on the subject's level of aspiration. The computer will be used to find significant correlations between the above variables and the job satisfaction scores. (Robert W. Storm)

1526-56046 Psychiatrics. Implicit Personality Theories of Psychiatric Personnel. It has been proposed that a fruitful approach to the problems of inter-personal perception is investigation of the trait dimensions by which individuals organize their perceptions of other people. These dimensions may be thought of as defining a perceptual space and comprising an implicit personality theory. Typically the operations for determining them begin with obtaining correlations between various traits ascribed to people and analyzing inter-judge differences in these correlations.

The present study aims to explore the implicit personality theories by which mental health professionals organize their perceptions of psychiatric patients. Ratings by two sets of judges (psychiatric unit staff) of standard sets of patients have been obtained. The calculations involve computing the correlations between all items and extracting the underlying dimensions by factor analysis of the correlation matrix. An exploration of possible individual differences will be made by factoring a matrix for each judge as well as a matrix involving each set of judges. (Arthur S. Elstein)

1527-56047 T Zoology. Energy requirements and Nitrogen Balance During Molt in the House Sparrow, Passer domesticus. Captive house sparrows, Passer domesticus, were subjected to controlled conditions in the laboratory at three temperatures under four photoperiodic regimes, and measurements made of the weight, fat class, energy metabolized, and nitrogen balance before, during, and after molt. The data will be analyzed by the method of least squares. (Floyd H. Blackmore)

1528-56048 T Economics. Risk and Liquid Assets. This research problem will test the effects of risk, yield, firm size, and other select variables on the holdings of liquid assets by business firms. The data is balance sheet and income statement data from approximately 250 large U.S. corporations for a 10 year period. Values for the variables will be computed from the data by the appropriate arithmetic operations. The relationships between the variables have been established theoretically and will be tested with cross section multivariate linear regression and correlation analysis. The regression routine is a standard library routine. (John O. Bornhofen)

1529-56049 University High School. Factors in Guidance Programs. Results of tests made on experimental instruments are to be analyzed using the three following statistical methods: 1) tabulation of results of experimental instruments (item means, factor analysis, factor means) over various forms of a scale of 50 items with 5 multiple answers; 2) comparison of pre-test results with post-test data by t-test of means and analysis of variance; and 3) comparison of pre-test results with post-test results by chi-square. (W. M. Rogge)

1530-56052 Sociology. Social Control Agency Interaction. Data from 743 social control personnel (police, probation officers, etc.) in three communities were collected. Data collected concerned frequency of inter-agency interaction, evaluations of agency personnel by the personnel, and personal and professional characteristics of the personnel. Analysis of data will be directed toward identifying determinants of levels of interaction by standard correlation and analysis of variance procedures available in the SSUPAC library. (Clark)

1531-56053 T Animal Science. Effect of Protein on Antibody Production in Swine. Antibody response in swine as affected by levels of dietary protein and amino acids was studied. Least squares is to be used in analyzing the data. (J. J. McGillivray)

1532-56054 Political Science. 1960 Election Study. The research involved a study of conflict behavior of Champaign-Urbana voters in the 1960 Presidential election. Approximately 380 individuals were interviewed in June, July, August, and October of 1960. An attempt was made to locate and analyze those in conflict over their presidential vote intentions.

Standard SSUPAC routines will be used, including frequency counting, correlation programs, and factor analytic programs. (Denis G. Sullivan)

1533-56055 T Electrical Engineering. Research on Sampled-Data System. The problem is to find the optimum controller for sampled data control systems. The methods which will be used are the Maximum Principle and Dynamic Programming. The computer will be used in solving differential equations and nonlinearities. (B. C. Kuo)

1534-56056 Department of Computer Science. Anharmonic Oscillator Calculations. These calculations will be used to study the equilibrium behavior of anharmonic oscillators. Some of these calculations will involve the numerical evaluation of Wiener integrals using Monte Carlo techniques. (Pete Stuckey)

1535-56058 Health Education. School Health Education Study. The School Health Education Study is a study of health instruction in the elementary and secondary schools of the United States. The second phase of this national research project is concerned with the evaluation of experimental health instruction materials. The research design adopted to test these materials involves three parallel groups or 1) an experimental group and 2) control groups. Three different test instruments have been employed to measure the pre-test, post-test gain scores. The analysis of co-variance test will be used to make the gain-score comparisons. (W. H. Creswell, Jr.)

1536-56059 T Forestry. Lumber Distribution. This study deals with the distribution of lumber and the price differentials between specified regions of the United States. After determining the lumber surplus or deficit regions and the physical quantities involved, the transportation rates and the restrictions regarding types of shipments, the problem is set up as a linear programming model. This will be a typical transportation problem in this field and the computer will determine the optimum flows of lumber to minimize total transportation costs. This will be done for the year 1965 and for an as yet undetermined year in the future on an estimated basis. (Alec Albee)

1537-56060 T Physics. Normal-Superconducting Interface Energy. The research subject under consideration is the surface free energy associated with a plane interface between normal and superconducting regions of a material. The surface free energy is simply that part of the magnetic Gibbs free energy which is proportional to the interface area. The calculation should apply for any interface between macroscopic normal and superconducting regions which has a radius of curvature much greater than the coherence distance for the material. The starting point of the theoretical calculation is the Gon'kov equations, a pair of coupled, second order, ordinary differential equations, which constitute an eigenvalue problem. Certain of the eigenfunctions of these equations, once obtained, are used to calculate the pair potential (gap parameter) as a function of position normal to the interface. The pair potential in turn is used in the calculation of the surface free energy. It is desired to calculate the surface free energy for a range of materials and temperatures sufficient to make comparison with the experimental values feasible and meaningful. In both steps of the calculation, there occur one-dimensional integrals with complex argument. It is not practicable, except in limiting cases, to do these integrals by hand or by desk calculator, because: (1) the integrals are quite complicated; (2) the integrals must be done for a rather large number of different sets of values for the parameters which characterize the material and the temperature. Thus it is desired to make use of the computer facilities to carry out the necessary integrations. Standard library subroutines will be sufficient for the problem at hand. (W. N. Mathews, Jr.)

1538-56061 Health Service. AMA Smoking Freshmen. University freshmen represent a portion of the population that could in the future exercise a strong influence on the young adult population as well as future generations.

This study includes 3573 freshmen students enrolled in Rhetoric 101 during the 1964-65 fall semester. The data were collected through a precoded self-administered questionnaire and the Student Data System. The 110 selected factors may elicit sufficient data to indicate some trends or factors having evidence of association or a significant

influence on the smoking habits of freshmen at the University of Illinois, Urbana. Variables include information on size of high school attended, geographic location, mobility of residency, financing university education, membership in high school and college organizations, education level of parents, attitude of parents and peers regarding smoking, and academic achievement.

Through the use of standard library routines (SSUPAC), analysis of the data includes cross tabulation of frequencies, points of central tendency, coefficients of correlation, standard errors and regression coefficients. (Dorthy Dunn)

6.3 Instructional Problem Specifications

During the second quarter of 1965, 6 instructional problem specifications were submitted to the IBM 7094 for calculation. The following brief descriptions of these problems have been prepared for inclusion in this report by those submitting them.

I168-54040 Aeronautical and Astronautical Engineering 418. Rarefied Gas Flows. The student will use the computer to evaluate (1) the parameters of collision geometry for certain collision laws, and (2) the collision parameters for rarefied gas flow problems that deviate appreciably from thermodynamic equilibrium. Some subroutines will be developed for future use. (S.M. Yen)

I169-55006 Civil Engineering 363. Problem No. 1. Students will be assigned the design of a steel building. The STRESS programming system will be used by the students to analyze their initial design configuration, as well as any modifications indicated by the analysis. (J. P. Cannon)

I170-55012 Sociology 326. Income Differences and the Distribution of Negro Professionals. The proposed research makes use of the one in 1000 sample data from the U. S. 1960 Census. One of the two objectives is to analyze income differences by region, with special reference to persons employed in lower white collar occupations and skilled workers. The second objective is to ascertain regional distribution of Negro professionals with special reference to educational attainment. (H. Y. Tien)

I171-55034 Physics 303. Data Analysis for Experimental Modern Physics Laboratory. Treatment of experimental data - fitting the best polynomial to a set of data and least square analysis of data. (W. Dale Compton)

I172-56031 Civil Engineering 497. Problem No. 2. Analytical Aerotriangulation. The problems involved in this Special Problems Course are all related to Analytical Aerotriangulation, and consist essentially of determining the object space coordinates and orientation matrices for all the photographs in the photogrammetric system, on the basis of the observations made in the image coordinate system on the Stereocomparator. The work involves the formation and adjustment of photographic strips and blocks of strips covering test areas, and statistical analyses of the residual errors in the corrdinates (x,y, and z) of check points. (H. M. Karara)

I176-56057 Finance 454. Financial Ratio Analysis. The computer time is to be used in running the Financial Ratio Analysis Program (FRAPI) developed specifically for the graduate/undergraduate courses in financial analysis. The Program is designed to save computational time for the student. (Paul J. Swanson, Jr.)

Table I - IBM 1401-I

Summary of Use

April, 1965

Scheduled Engineering	10:47
Unscheduled Engineering	21:48
Maintenance	10:09
7094 Preparation	472:58
Listing	17:42
Code Check	19:36
Tape Duplication	2:40
Tape Dump	7:04
Reproduce	20:30
SMP	13:24
1604 Preparation	:03
Tape Testing	:10
Tape Label	1:30
Illiac Preparation	11:00
Idle	20:45
Total	630:06

Table II - IBM 1401-I

Summary of Machine Errors

April, 1965

1401 Main Frame	1
1402 Card Reader Punch	10
1403 Printer	8
729 V Tape Drive	5
Total	24

Table I - IBM 1401-II

Summary of Use

April, 1965

Scheduled Engineering	1:15
Unscheduled Engineering	33:42
Maintenance	9:41
7094 Preparation	427:00
Listing	26:18
Code Check	14:27
Tape Duplication	3:55
Tape Dump	11:58
Reproduction	21:46
SMP	5:26
1604 Preparation	:05
Tape Testing	16:53
Tape Label	2:55
Illiac Preparation	7:26
Idle	29:22
Total	613:09

Table II - IBM 1401-II

Summary of Machine Errors

April, 1965

1401 Main Frame	1
1402 Card Reader Punch	14
1403 Printer	8
729 V Tape Drive	2
Total	25

Table I - IBM 7094

Summary of Use

April, 1965

Scheduled Engineering				20:20
Unscheduled Engineering				11:54
Machine Maintenance				14:02
Air Conditioning				3:52
Idle				20:56
Miscellaneous (Operating, tape rewind, tape skipping, tape mounting, both system and user, rerun of failing problems, destruction of clock reading)				57:58
Total Use				
Training and Education			36:58	
University Administrative Overhead Use			14:12	
University Administrative Overhead Use (Relinquish)			:17	
System Modification and Improvement			23:00	
System Modification and Improvement (Relinquish)			19:53	
System Updating			7:02	
System Updating(Relinquish)			3:04	
Customer Use				
In System		289:34		
Relinquish				
AGEC	25:02			
CHE	:07			
DCS	:50			
PHYCS	66:47			
		92:46		
Special Short Shots		1:11		
	Customer Use		383:31	
	Total Use			487:57
	Total Time On			616:59

Table II - IBM 7094

Summary of Machine Errors

April, 1965

716 On-Line Printer	2
721 On-Line Card Punch	1
729 VI Tape Drive	11
7631 File Control	1
7094 Console Key	1
7110 Processing Unit	1
Air Conditioning	3
Miscellaneous	1
Total	21

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	TandE[2]	Res	Total	TandE[2]	Res	Total	TandE[2]	Res	Total
AAE	127	153	280	3	7	10	1 17.2	4 30.1	5 47.3
ADV	0	43	43	0	1	1	0.0	24.6	24.6
AGE	49	44	93	2	2	4	11.8	1 13.3	1 25.1
AGEC	0	354	354	0	24	24	0.0	34 55.8	34 55.8
AGRON	0	189	189	0	14	14	0.0	11 12.9	11 12.9
ANGEN	0	1	1	0	1	1	0.0	0.1	0.1
ANS	0	109	109	0	3	3	0.0	4 50.3	4 50.3
ANTH	109	1	110	2	1	3	2 56.8	0.3	2 57.1
ASTR	0	31	31	0	1	1	0.0	14.9	14.9
BECBS	0	59	59	0	3	3	0.0	35.6	35.6
BEDRE	0	24	24	0	1	1	0.0	13.6	13.6
BIOPH	0	12	12	0	1	1	0.0	13.4	13.4
BOT	0	16	16	0	3	3	0.0	21.1	21.1
CE	508	843	1351	4	36	40	3 13.6	22 16.0	25 29.6
CHE	99	1506	1605	2	51	53	40.3	44 33.1	45 13.4
CRC	0	9	9	0	1	1	0.0	31.1	31.1
CSL	0	3	3	0	1	1	0.0	0.4	0.4
CZR	0	6	6	0	1	1	0.0	11.0	11.0
DCS	332	119	451	2	9	11	2 37.4	3 56.8	6 34.3
DNSTU	0	21	21	0	1	1	0.0	9.8	9.8
DS	0	176	176	0	4	4	0.0	2 20.3	2 20.3
DUE	15	1	16	1	1	2	2.9	1.9	4.9
ECON	33	133	166	2	6	8	35.5	7 21.4	7 57.0
ED	5	136	141	1	5	6	6.6	4 38.6	4 45.3
EDPSY	0	2	2	0	1	1	0.0	3.6	3.6
EDTES	0	17	17	0	1	1	0.0	33.8	33.8
EE	924	922	1846	6	21	27	8 31.1	26 8.2	34 39.3
FIN	4	0	4	1	0	1	0.4	0.0	0.4
FOR	0	10	10	0	1	1	0.0	7.8	7.8
FT	0	10	10	0	1	1	0.0	5.0	5.0
GENE	181	0	181	3	0	3	1 27.9	0.0	1 27.9
GEOG	0	3	3	0	1	1	0.0	4.9	4.9
GEOL	0	9	9	0	2	2	0.0	2.6	2.6
GSBA	98	0	98	2	0	2	2 0.2	0.0	2 0.2
HORT	0	29	29	0	3	3	0.0	34.9	34.9
ICR	0	72	72	0	3	3	0.0	1 19.9	1 19.9

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	TandE[2]	Res	Total	TandE[2]	Res	Total	TandE[2]	Res	Total
IE	0	9	9	0	1	1	0.0	7.9	7.9
IGPA	0	20	20	0	2	2	0.0	32.8	32.8
ILR	0	6	6	0	2	2	0.0	1.4	1.4
INADM	5	44	49	1	2	3	7.2	58.3	1 5.5
IREC	0	19	19	0	3	3	0.0	35.6	35.6
MATH	230	0	230	2	0	2	58.0	0.0	58.0
ME	1056	745	1801	15	25	40	8 28.4	16 13.9	24 42.4
MKTG	0	2	2	0	1	1	0.0	17.6	17.6
MMPE	37	111	148	2	4	6	14.3	2 12.2	2 26.6
MRL	0	1	1	0	1	1	0.0	5.3	5.3
MUSIC	0	55	55	0	1	1	0.0	17.3	17.3
NHS	0	1	1	0	1	1	0.0	0.2	0.2
NUCE	164	225	389	2	11	13	2 30.5	4 47.4	7 17.9
OIR	0	200	200	0	4	4	0.0	5 54.7	5 54.7
PEM	0	18	18	0	2	2	0.0	8.9	8.9
PEW	0	6	6	0	1	1	0.0	27.4	27.4
PHYCS	9	2032	2041	2	33	35	2.7	140 27.5	140 30.2
PHYSL	0	2	2	0	1	1	0.0	0.4	0.4
POLS	2	5	7	1	1	2	0.6	3.0	3.7
PSYCH	0	781	781	0	34	34	0.0	15 2.5	15 2.5
SCONS	0	84	84	0	2	2	0.0	1 15.5	1 15.5
SCS	0	39	39	0	1	1	0.0	1 19.0	1 19.0
SGS	0	13	13	0	1	1	0.0	6.2	6.2
SOC	12	0	12	1	0	1	7.9	0.0	7.9
SPCH	0	1	1	0	1	1	0.0	3.2	3.2
SWS	0	141	141	0	14	14	0.0	7 4.3	7 4.3
TAM	118	262	380	5	8	13	45.8	10 5.6	10 51.5
VMS	0	20	20	0	1	1	0.0	9.8	9.8
WPGU	0	5	5	0	1	1	0.0	5.9	5.9
XSSS[3]	0	179	179	0	1	1	0.0	1 11.2	1 11.2
ZOOL	0	8	8	0	1	1	0.0	4.5	4.5
Subtotal	4117	10097	14214	62	373	435	36 58.3	383 30.6	420 29.0
DCSYS[4]	0	1103	1103	0	20	20	0.0	42 53.3	42 53.3
XDCS[5]	0	59	59	0	1	1	0.0	10 5.9	10 5.9
SSUAD[6]	0	585	585	0	2	2	0.0	14 28.3	14 28.3
Total	4117	11844	15961	62	396	458	36 58.3	450 58.1	487 56.5

1 See list of departmental codes following
2 Training and Education
3 Special Studies Unit
4 System Improvement and Modifications
5 System Updating
6 Special Studies Unit Administrative Data

TABLE I - IBM 1401-I
SUMMARY OF USE
May, 1965

Scheduled Engineering	2:40
Unscheduled Engineering	29:26
Maintenance	4:41
7094 Preparation	502:34
Listing	25:30
Code Check	21:41
Tape Duplication	1:15
Tape Dump	6:49
Reproduction	10:58
SMP	14:32
1604 Preparation	:18
Tape Testing	2:45
Tape Label	:30
Illiac Preparation	14:50
Idle	5:51
Total	644:20

TABLE II - IBM 1401-I
SUMMARY OF MACHINE ERRORS
May, 1965

1402 Card Reader Punch	8
1403 Printer	2
729V Tape Drives	3
Total	13

TABLE I - IBM 1401-II
SUMMARY OF USE
May, 1965

Scheduled Engineering		3:45
Unscheduled Engineering		19:16
Maintenance		5:10
7094 Preparation		458:13
Listing		35:47
Code Check		15:18
Tape Duplication		2:55
Tape Dump		8:42
Reproduction		18:44
SMP		20:54
Tape Testing		3:35
Tape Label		2:30
Illiac Preparation		22:41
Idle		10:30
	Total	628:00

TABLE II - IBM 1401-II
SUMMARY OF MACHINE ERRORS
May, 1965

1402 Card Reader Punch		14
1403 Printer		2
729V Tape Drives		2
	Total	18

TABLE I - IBM 7094

Summary of Use

May, 1965

Scheduled Engineering	15:17
Unscheduled Engineering	4:09
Maintenance	13:30
Idle	8:44
Miscellaneous (Operator training, tape rewind, tape mounting, both system and user, rerun of failing problems, tape skipping)	49:20

Total Use

Training and Education			56:48
University Administrative Overhead Use			11:04
System Modification and Improvement			25:31
System Modification and Improvement (Relinquish)			22:40
System Updating			4:41
System Updating (Relinquish)			3:51

Customer Use

In System		286:31	
Relinquish			
AGEC	52:40		
DCS	:10		
GSBA	:19		
PHYCS	68:39		
		121:48	
Special Short Shots		:40	
Customer Use			408:59
		Total Use	533:34
		Total Time On	624:34

TABLE II - IBM 7094

Summary of Machine Errors

May, 1965

729 VI Tape Drive	15
7608 Power Converter	1
7094 Undetermined Errors	2
Total	18

7094 Table III May 1965

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	TandE[2]	Res	Total	TandE[2]	Res	Total	TandE[2]	Res	Total
AAE	186	166	352	4	7	11	4 27.8	3 28.7	7 56.6
ADV	0	16	16	0	1	1	0.0	25.7	25.7
AGE	220	73	293	2	5	7	1 10.3	1 25.4	2 35.8
AGEC	0	378	378	0	24	24	0.0	63 27.3	63 27.3
AGRON	0	112	112	0	16	16	0.0	4 37.0	4 37.0
ANGEN	0	3	3	0	1	1	0.0	0.5	0.5
ANS	0	84	84	0	3	3	0.0	4 47.1	4 47.1
ANTH	166	0	166	2	0	2	1 36.7	0.0	1 36.7
ASTR	0	58	58	0	1	1	0.0	24.6	24.6
BECBS	0	101	101	0	2	2	0.0	54.7	54.7
BEDRE	0	21	21	0	1	1	0.0	7.8	7.8
BIOPH	0	7	7	0	1	1	0.0	4.9	4.9
BOT	0	78	78	0	2	2	0.0	2 28.6	2 28.6
CE	852	1303	2155	5	40	45	6 52.1	26 46.9	33 39.1
CHE	119	1314	1433	1	44	45	46.7	50 34.6	51 21.4
CRC	0	5	5	0	1	1	0.0	2.3	2.3
CZR	0	3	3	0	1	1	0.0	1.0	1.0
DCS	268	141	409	2	8	10	3 0.7	5 29.4	8 30.1
DNSTU	0	172	172	0	1	1	0.0	1 3.8	1 3.8
DS	0	127	127	0	5	5	0.0	1 39.4	1 39.4
DUE	83	2	85	1	1	2	33.1	0.7	33.8
ECON	31	68	99	3	5	8	14.8	2 8.1	2 22.9
ED	23	110	133	1	6	7	1 14.5	2 34.7	3 49.2
EDPSY	0	2	2	0	1	1	0.0	3.1	3.1
EDTES	0	12	12	0	1	1	0.0	48.5	48.5
EE	565	755	1320	7	19	26	4 47.6	23 50.5	28 38.2
FIN	29	0	29	1	0	1	9.7	0.0	9.7
FOR	0	3	3	0	1	1	0.0	3.6	3.6
FT	0	13	13	0	1	1	0.0	4.6	4.6
GENE	176	1	177	3	1	4	2 9.1	0.1	2 9.3
GEOG	0	7	7	0	1	1	0.0	5.6	5.6
GSBA	267	0	267	3	0	3	6 10.3	0.0	6 10.3
HORT	0	25	25	0	1	1	0.0	52.8	52.8
ICR	0	78	78	0	3	3	0.0	2 2.1	2 2.1

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	TandE[2]	Res	Total	TandE[2]	Res	Total	TandE[2]	Res	Total
IE	0	30	30	0	1	1	0.0	31.5	31.5
IED	0	8	8	0	1	1	0.0	2.6	2.6
IGPA	0	55	55	0	2	2	0.0	1 29.2	1 29.2
ILR	0	11	11	0	2	2	0.0	10.3	10.3
INADM	0	39	39	0	2	2	0.0	34.4	34.4
IREC	0	35	35	0	4	4	0.0	34.6	34.6
LIBS	0	13	13	0	3	3	0.0	1 12.1	1 12.1
MATH	925	0	925	2	0	2	4 35.5	0.0	4 35.5
MCBIO	0	1	1	0	1	1	0.0	2.7	2.7
ME	1014	717	1731	13	26	39	10 57.1	14 53.0	25 50.2
MKTG	0	3	3	0	1	1	0.0	11.2	11.2
MMPE	65	66	131	2	5	7	17.8	36.8	54.7
MRL	0	4	4	0	1	1	0.0	29.5	29.5
MUSIC	0	37	37	0	1	1	0.0	11.0	11.0
NHS	0	1	1	0	1	1	0.0	0.3	0.3
NUCE	173	285	458	2	10	12	3 51.7	4 11.6	8 3.3
OIR	0	216	216	0	4	4	0.0	6 40.3	6 40.3
PEM	0	6	6	0	2	2	0.0	21.7	21.7
PEW	0	9	9	0	1	1	0.0	49.6	49.6
PHIL	3	0	3	1	0	1	4.0	0.0	4.0
PHYCS	20	1991	2011	3	32	35	5.3	145 53.6	145 59.0
POLS	92	8	100	1	2	3	2 7.1	8.2	2 15.4
PSYCH	0	580	580	0	36	36	0.0	16 35.6	16 35.6
REC	0	2	2	0	1	1	0.0	1.5	1.5
SCONS	0	114	114	0	2	2	0.0	1 32.9	1 32.9
SCS	0	20	20	0	1	1	0.0	1 26.3	1 26.3
SGS	0	13	13	0	1	1	0.0	5.6	5.6
SOC	20	7	27	2	1	3	16.2	4.5	20.8
SOCW	0	4	4	0	2	2	0.0	2.6	2.6
SWS	0	151	151	0	10	10	0.0	3 47.0	3 47.0
TAM	237	230	467	5	9	14	1 18.9	4 30.1	5 49.1
VMS	0	30	30	0	1	1	0.0	17.7	17.7
WPGU[3]	0	3	3	0	1	1	0.0	4.6	4.6
XSSS[3]	0	154	154	0	1	1	0.0	39.7	39.7

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	TandE[2]	Res	Total	TandE[2]	Res	Total	TandE[2]	Res	Total
ZOOL	0	7	7	0	3	3	0.0	18.2	18.2
Subtotal	5534	10088	15622	66	376	442	56 48.2	408 58.4	465 46.7
DCSSY[4]	0	1137	1137	0	20	20	0.0	48 11.3	48 11.3
XDCS[5]	0	60	60	0	1	1	0.0	8 32.1	8 32.1
SSUAD[6]	0	434	434	0	2	2	0.0	11 4.0	11 4.0
Total	5534	11719	17253	66	399	465	56 48.2	476 45.8	533 34.1

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Improvement and Modifications
5 System Updating
6 University Administrative Overhead Use

TABLE I - IBM 1401-I

Summary of Use

June, 1965

Scheduled Engineering	35:11
Unscheduled Engineering	6:15
Maintenance	7:16
7094 Preparation	437:22
Listing	18:56
Code Check	21:14
Tape Duplication	:20
Tape Dump	6:07
Reproduction	10:58
SMP	22:17
Tape Testing	1:35
Tape Label	1:15
Illiac Preparation	:35
Idle	29:37
General Power Failure	1:49
	600:47

TABLE II - IBM 1401-I

Summary of Machine Errors

June, 1965

1401 Main Frame	1
1402 Card Reader Punch	6
1403 Printer	1
729 V Tape Drives	5
General Power failure	2
	15

TABLE I - IBM 1401-II

Summary of Use

June, 1965

Scheduled Engineering	13:02
Unscheduled Engineering	8:49
Maintenance	7:01
7094 Preparation	452:32
Listing	32:40
Code Check	9:17
Tape Duplication	1:00
Tape Dump	6:56
Reproduction	19:07
SMP	25:25
1604 Preparation	:10
Tape Testing	1:45
Tape Label	1:05
Illiac Preparation	1:18
Idle	27:13
Building Power Failure	1:49
Total	609:09

TABLE II - IBM 1401-II

Summary of Machine Errors

June, 1965

1402 Card Reader Punch	12
1403 Printer	2
729 V Tape Drives	3
General Power Failure	2
Total	19

TABLE I - IBM 7094

Summary of Use

June, 1965

Scheduled Engineering			27:06
Unscheduled Engineering			4:56
Machine Maintenance			14:40
Air Conditioning			20:04
Idle due to Power Failure			1:46
Idle			14:42
Miscellaneous (Operator training, tape rewind, tape mounting, both system and user, rerun of failing problems, tape skipping, destruction of clock reading)			49:58
Total Use			
Training and Education		10:56	
University Administrative Overhead Use		12:57	
System Updating		6:12	
System Modification and Improvement		40:48	
Customer Use			
In System	320:25		
Relinquish			
AGEC	17:37		
ED	:24		
PHYCS	93:52		
	111:53		
Special Short Shots	:28		
		432:46	
Total Use			503:39
Total Time On			636:51

TABLE II - IBM 7094

Summary of Machine Errors

June, 1965

729 VI Tape Drive	5
7302 Core Storage Unit	1
7608 Power Converter	1
Suspected Tape Errors	1
7094 Air Conditioning System	1
Building Power Failures	2
7094 Undetermined Errors	3
Total	14

7094 TABLE III June 1965

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	TandE[2]	Res	Total	TandE[2]	Res	Total	TandE[2]	Res	Total
AAE	4	196	200	1	8	9	7.4	4 27.1	4 34.6
ADV	0	152	152	0	1	1	0.0	3 9.1	3 9.1
AGE	9	88	97	2	6	8	4.1	2 55.6	2 59.7
AGEC	14	214	228	1	21	22	6.3	23 6.8	23 13.2
AGREX	0	1	1	0	1	1	0.0	1.0	1.0
AGRON	0	104	104	0	11	11	0.0	4 31.3	4 31.3
ANGEN	0	5	5	0	1	1	0.0	1.0	1.0
ANS	0	43	43	0	4	4	0.0	2 3.1	2 3.1
ANTH	39	0	39	2	0	2	39.7	0.0	39.7
ASTR	0	34	34	0	2	2	0.0	17.0	17.0
BECBS	0	121	121	0	3	3	0.0	1 9.7	1 9.7
BEDRE	0	80	80	0	1	1	0.0	53.6	53.6
BOT	0	4	4	0	1	1	0.0	3.2	3.2
CE	51	1630	1681	3	42	45	35.2	44 32.3	45 7.5
CHE	5	1365	1370	1	45	46	0.8	50 39.8	50 40.7
CRC	0	4	4	0	1	1	0.0	5.0	5.0
CZR	0	4	4	0	1	1	0.0	2.5	2.5
DCS	64	134	198	2	6	8	1 52.0	3 1.7	4 53.7
DNSTU	0	3	3	0	1	1	0.0	1.9	1.9
DS	0	155	155	0	5	5	0.0	1 43.2	1 43.2
DUE	28	4	32	1	1	2	10.4	3.1	13.6
ECON	0	17	17	0	3	3	0.0	23.5	23.5
ED	0	132	132	0	6	6	0.0	6 27.2	6 27.2
EDTES	0	6	6	0	1	1	0.0	4.0	4.0
EE	43	649	692	2	16	18	19.4	18 49.9	19 9.3
FIN	3	0	3	1	0	1	4.9	0.0	4.9
FOR	0	3	3	0	1	1	0.0	2.4	2.4
FT	0	1	1	0	1	1	0.0	0.1	0.1
GENE	38	1	39	3	1	4	42.6	0.1	42.8
GEOG	0	4	4	0	1	1	0.0	3.2	3.2
GEOL	0	1	1	0	1	1	0.0	0.4	0.4
GSBA	30	0	30	3	0	3	46.0	0.0	46.0
HORT	0	3	3	0	1	1	0.0	4.3	4.3
ICR	0	113	113	0	5	5	0.0	3 55.9	3 55.9

7094 TABLE III CONT. JUNE 1965

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	TandE[2]	Res	Total	TandE[2]	Res	Total	TandE[2]	Res	Total
IED	0	24	24	0	1	1	0.0	22.7	22.7
IGPA	0	21	21	0	1	1	0.0	22.7	22.7
INADM	0	23	23	0	2	2	0.0	26.6	26.6
IREC	0	26	26	0	5	5	0.0	44.8	44.8
LAW	0	4	4	0	1	1	0.0	13.0	13.0
LIBS	0	5	5	0	2	2	0.0	11.6	11.6
LIR	0	4	4	0	2	2	0.0	6.4	6.4
MATH	8	0	8	2	0	2	2.4	0.0	2.4
ME	114	692	806	6	23	29	1 18.2	26 15.8	27 34.1
MMPE	0	191	191	0	5	5	0.0	3 26.1	3 26.1
MRL	0	1	1	0	1	1	0.0	20.0	20.0
MUSIC	0	26	26	0	1	1	0.0	17.3	17.3
NHS	0	50	50	0	3	3	0.0	25.6	25.6
NUCE	93	222	315	2	11	13	2 58.5	6 1.7	9 0.2
OIR	0	273	273	0	3	3	0.0	8 19.9	8 19.9
PEM	0	3	3	0	2	2	0.0	4.7	4.7
PHYCS	3	2234	2237	1	32	33	2.0	179 31.6	179 33.7
POLS	47	31	78	1	5	6	54.1	1 38.2	2 32.4
PSYCH	0	764	764	0	39	39	0.0	17 0.4	17 0.4
REC	0	33	33	0	2	2	0.0	1 33.5	1 33.5
SCONS	0	89	89	0	2	2	0.0	2 17.3	2 17.3
SCS	0	5	5	0	2	2	0.0	22.4	22.4
SGS	0	17	17	0	1	1	0.0	7.1	7.1
SOC	0	28	28	0	2	2	0.0	38.8	38.8
SOCW	0	4	4	0	2	2	0.0	6.1	6.1
SPCH	0	11	11	0	2	2	0.0	7.5	7.5
SWS	0	101	101	0	12	12	0.0	2 49.2	2 49.2
TAM	9	316	325	3	7	10	11.1	4 3.6	4 14.8

7094 TABLE III CONT. JUNE 1965

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	TandE[2]	Res	Total	TandE[2]	Res	Total	TandE[2]	Res	Total
UNIHI	0	11	11	0	1	1	0.0	8.0	8.0
VPH	0	27	27	0	2	2	0.0	33.1	33.1
XSSS[3]	0	66	66	0	1	1	0.0	28.4	28.4
ZOOL	0	76	76	0	3	3	0.0	59.2	59.2
Subtotal	602	10649	11251	37	377	414	10 56.1	432 46.0	443 42.2
DCSSY[4]	0	896	896	0	20	20	0.0	40 47.8	40 47.8
XDCS[5]	0	45	45	0	1	1	0.0	6 12.4	6 12.4
SSUAD[6]	0	422	422	0	2	2	0.0	12 56.8	12 56.8
Total	602	12012	12614	37	400	437	10 56.1	492 43.0	503 39.2

1 See list of departmental codes following

2 Training and Education

3 Special short shots

4 System improvement and modifications

5 System updating

6 University administrative overhead use

7. GENERAL LABORATORY INFORMATION

7.1 Colloquia

"Trees: The Numerical Solution of Ordinary Differential Equations," by Professor J. C. Butcher, Stanford Linear Accelerator Center, Stanford University, Stanford, California, April 30, 1965.

"The Assignment of Sequencing of Computation on Parallel Processor Systems," by Mr. David Martin, Department of Engineering, University of California, Los Angeles, California, May 17, 1965.

"Parsing of Chomsky-Languages," by Professor Manfred Paul, Technische Hochschule, München, Germany, May 21, 1965.

7.2 Personnel

The number of people associated with the Laboratory in various capacities is given in the following table:

	Full-time	Part-time	Full-time Equivalent
Faculty	16	3	17.33
Visiting Faculty	4	-	4.0
Research Associates	2	0.5	2.5
Graduate Research Assistants	6	58	35.333
Graduate Teaching Assistants	-	3	1.25
Professional Personnel	4	2	6.0
Administrative and Clerical	13	1	13.5
Other Nonacademic Personnel	51	118	98.0
TOTAL	96	185.5	177.91

The Computer Advisory Committee consists of Professors P. G. Braunfeld, H. C. Brearley, R. M. Brown, J. R. Ehrman, L. D. Fosdick, H. G. Friedman, Jr., C. W. Gear, D. B. Gillies, N. T. Hamilton, B. H. McCormick, S. Muroga, T. A. Murrell, J. R. Pasta, W. J. Poppelbaum, S. R. Ray, J. E. Robertson, K. C. Smith and J. N. Snyder.

7.3 Drafting

During the quarter, a total of 300 drawings were processed by both drafting sections.

	General and ILLIAC II	Pattern Recognition
Large Drawings	7	1
Medium Drawings	11	22
Small Drawings	13	0
Report Drawings (415)	33	0
Report Drawings (Task 15)	23	0
Report Drawings (1018)	0	20
Change Orders	104	16
Layouts	0	22
Theses	4	0
Miscellaneous	24	0
TOTAL	219	81

(K. Law, L. Prendergast)

7.4 Shops' Production

Job orders processed and completed during the second quarter of 1965, are as follows:

Facility	AEC 415	AEC 1018	Other
Machine Shop	22	39	2
Electronic Shop	36	41	0
Etch Shop	12	27	0
Layout Shop	12	14	0

Wiring of 541 standard printed circuit boards and 6,475 baby boards during this period accounted for 82,190 diodes and 21,156 transistors.

0.84
lot
-1018-1066

Physics

COO-1018-1066
COO-1469-0012

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QUARTERLY TECHNICAL PROGRESS REPORT

July, August, September 1965

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QUARTERLY TECHNICAL PROGRESS REPORT

July, August, September 1965

Department of Computer Science
University of Illinois
Urbana, Illinois

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NUMBERING SYSTEM FOR PARTS 1 AND 2

To simplify assembly, eliminate errors and make possible the look-up of work by project or author, Parts 1 and 2 now use a new redundant numbering system. Each sub-section is ordered by a number consisting of four (one or two-digit) decimal groups of the form A, B, C, D. These groups represent in order:

A: The contract
B: The project
C: The author
D: The sub-section.

The first three groups are determined from Tables 1 through 3 and group D is simply the naturally occurring sub-section number in an author's report.

Table 1: Contract Number (First number)

Task 1834-15	1
Contract 1469--Hardware	2

Table 2: Project Number (Second number)

Paramatrix	01
Electro-Optics	02
Random Sequence Coding	03
Film Scanner	04
Tunneling Theory	05
Artrix	10
Photochromic Storage	11
Pattern Transform Analysis	12

Table 3: Author Number (Third number)

Afuso, C.	01
Carr, E.	02
Casasent, D.	03
Cieslak, R.	04
Esch, J.	05
Faiman, M.	06
Koo, D.	07
Kubitz , W.	08
Oberbeck, P.	09
Poppelbaum, W.	10
Rollenhagen, D.	11
Sand, D.	12
Smith, J.	13
Whiteside, S.	14

Note: As new projects and authors occur, Tables 2 and 3 will be expanded.

Figures will be numbered in the natural order for each author. If cross-references are needed, it will be necessary to precede the figure number by the three groups representing contract, project and author. A similar correction holds for equations, provided the author sees fit to number them.

The absence of the fourth group indicates a general statement about the authors work.

W. J. Poppelbaum
Editor, Parts 1 and 2

1. CIRCUIT RESEARCH PROGRAM

(Supported in part by the Office of Naval Research under Contract Nonr-1834(15).)

Summary

The main areas of research were: The Paramatrix System (David Casasent, Edward Carr), the Electro-Optical Work (Dick Koo, Steven Whiteside), Random Sequence Coding (Chushin Afuso) and the Film Scanner (Ronald Cieslak).

Efforts in the Paramatrix System have been concentrated on the check-out of the Interpolator.

In the Electro-Optical Work a new fast infrared detecting circuit is described. Some modifications have been made to the optical differential amplifier and several experiments are proposed for its use.

Detailed experimental results of the Random Sequence Coding are presented showing very close agreement with theory.

The Film Scanner project is now complete and the entire system is described.

1.01 Paramatrix System

1.01.03.1 The Interpolator

The Paramatrix Interpolator, as described in the last Quarterly Technical Progress Report and shown in Figure 1, has been built. This report describes some changes to it that were seen to be necessary in the course of check-out; these changes are now being made.

It will be recalled that Paramatrix operates on a line drawing (input picture) that can be broken down into four single-valued functions, $f_\ell(x)$, where $\ell = 1, 2, 3, 4$. The coordinates of these functions are represented by their voltage analogs x_k (abscissa) and $f_\ell(x_k)$ (ordinate), where $k = 0, 1, 2, \ldots, 31$. The voltage scale is given by $x_k - x_{k-1} = 0.5$ volt and $x_0 = -7.5$ volts. Corresponding to a point on the display matrix given by (voltage analog) coordinates x_i and y_j, the Transformer generates the voltages:

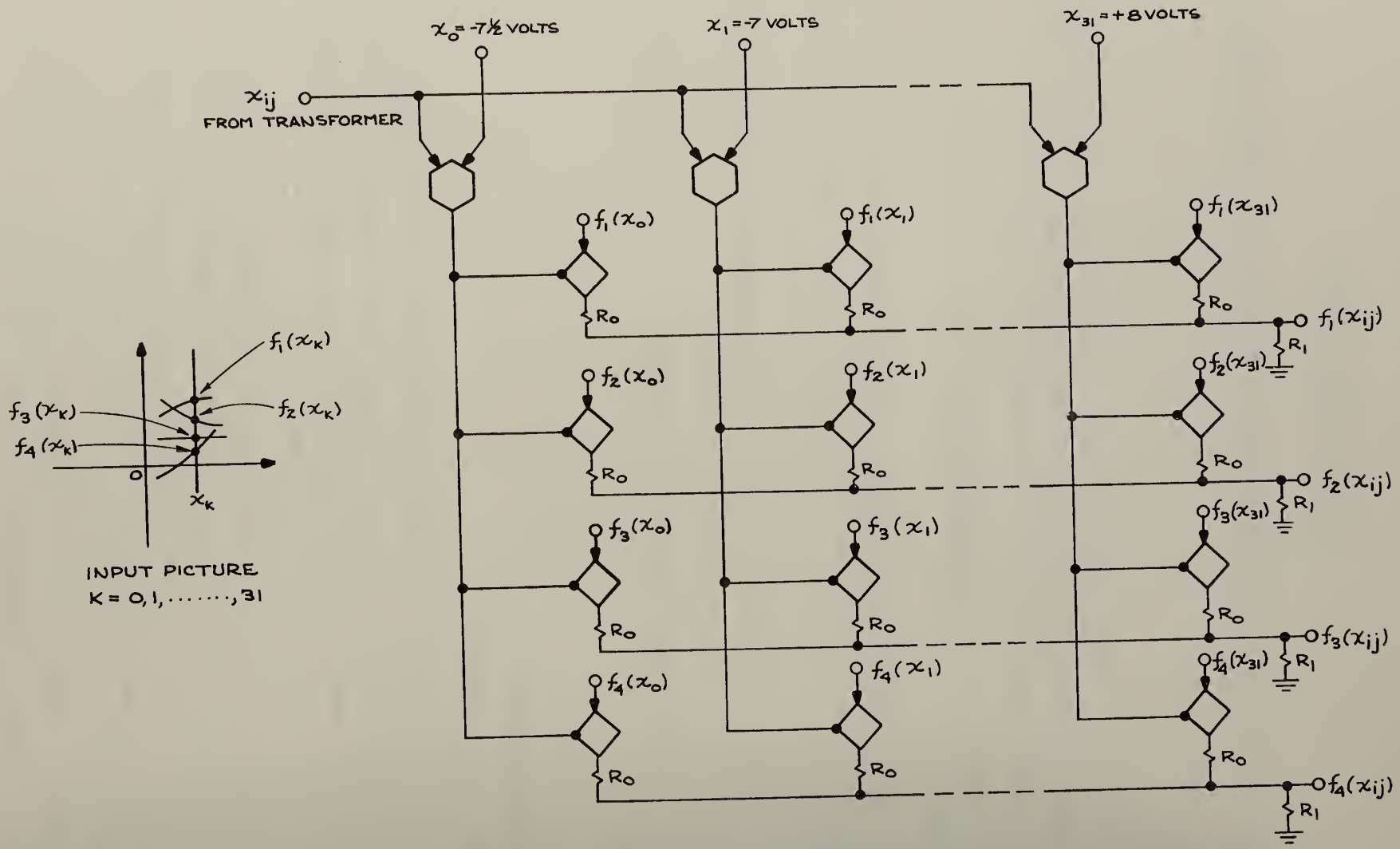


Figure 1. Paramatrix Interpolator

$$x_{ij} = m(X_i \cos\theta - Y_j \sin\theta) + a;$$

$$y_{ij} = n(X_i \sin\theta + Y_j \cos\theta) + b$$

The function of the Interpolator is then to compare x_{ij} with all the x_k so as to produce reasonable approximations for the $f_\ell(x_{ij})$. This is evidently accomplished by setting the sensitivity of the comparator circuit (top of Figure 1) to somewhere between 0.25 and 0.5 volt.

1.01.03.2 Doubly Gated Diamond Circuit

The problem arises of how to represent a particular $f_\ell(x_k)$ corresponding to no information, i.e., the case where for abscissa x_k there is no point on the input picture. One possibility would be to allow $f_\ell(x_k)$ to assume a voltage outside the allowable range of -7.5 to +8.0 volts, but this would in some instances lead to this disallowed voltage being averages within the Interpolator, with consequent errors in the display. Another possibility is to simulate the "no information" state with a switch at the input of each Diamond Circuit in the Interpolator. However, when such an input is open-circuited and the Diamond is turned on, any difference in the bias currents flows into the high impedance load formed by R_0 and R_1 and sets up a spurious voltage, which again leads to errors. The only reliable solution is to demand that the input picture scanning mechanism generate a digital signal to indicate the presence or absence of information and to use the modified Diamond Circuit of Figure 2 in which G_1 is driven by a Comparator circuit and G_2 by the digital signal from the scanner. In the present phase of Paramatrix this digital signal is provided by a switch.

1.01.03.3 Changes to Interpolator

The resistors R_1 in Figure 1 are now returned to -10v instead of ground. This ensures that, when x_{ij} is out of range so that all Comparators are off, the $f_\ell(x_{ij})$ drop to -10v to prevent them from registering a spurious agreement with y_{ij} in the Coincidence Unit.

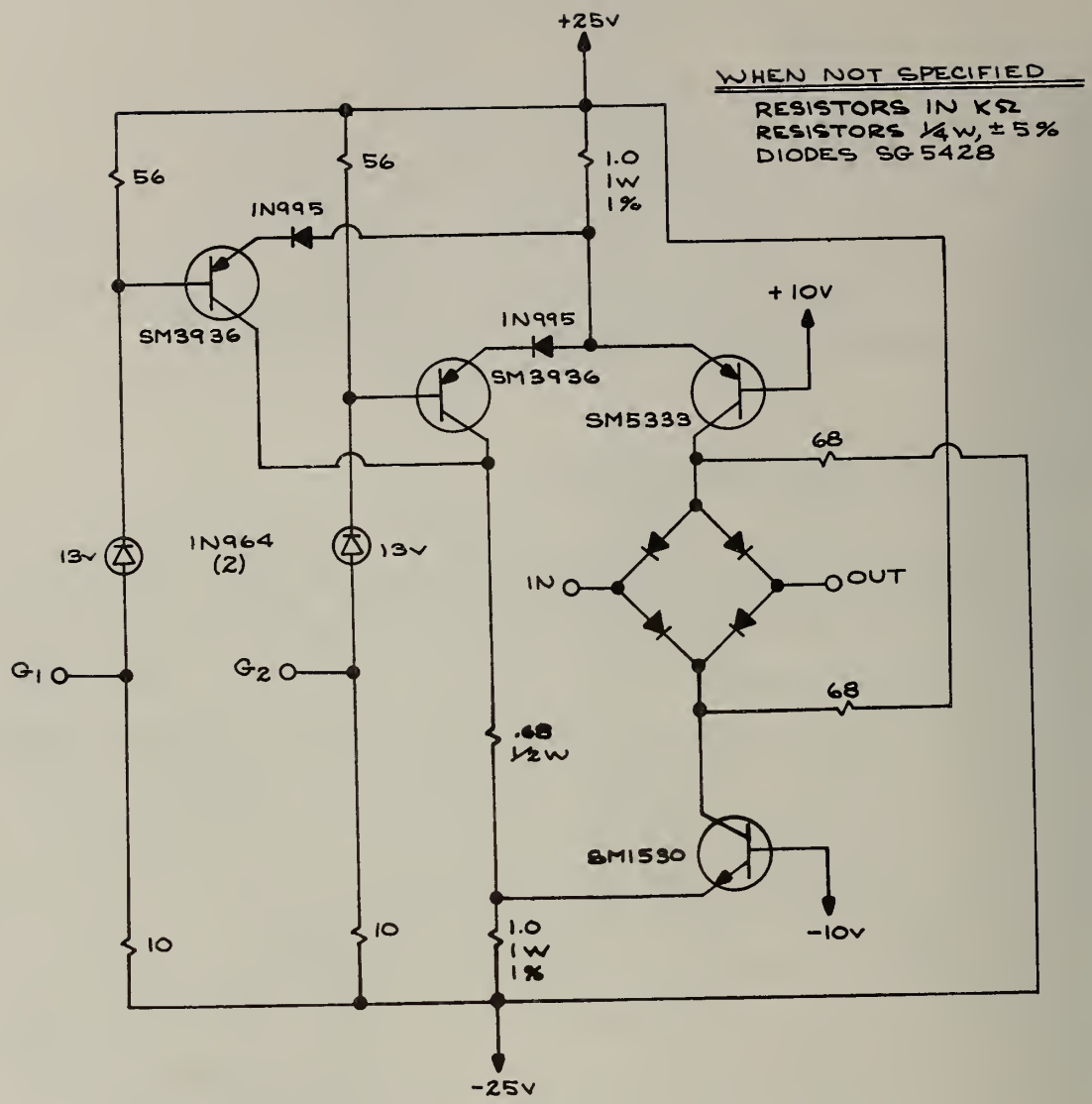


Figure 2. Doubly Gated Diamond Circuit

1.01.03.4 The Comparator Circuit

Some variation in sensitivity among Comparator circuits has been measured and was found to be caused by the tolerances of the individual circuit components. This is being cured by adjusting a collector resistor and current source resistor in the front end of each comparator circuit, so as to ensure that all circuits have identical properties.

The circuit for varying the sensitivity of a group of Comparators from about 0.1 to 2.0 volts is shown in Figure 3.

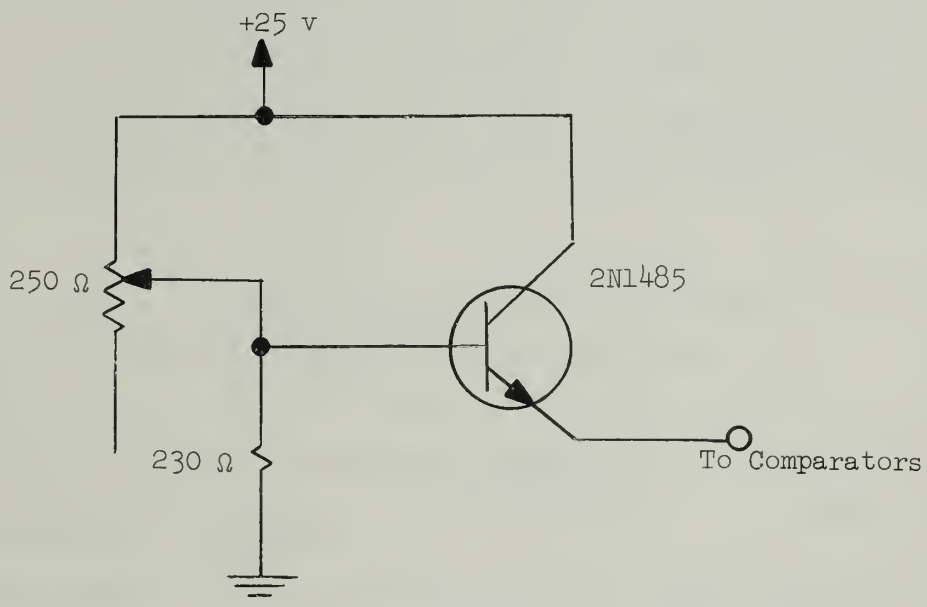


Figure 3. Sensitivity Control for Comparators

The Interpolator, Thinner and Coincidence Unit each require one such circuit.

1.02 Electro-Optical Work

1.02.07 Keldysh Effect Modulator

1.02.07.1 Fabrication of GaAs Diodes

Several samples of GaAs diodes have been prepared by the process described in the last Quarterly Technical Progress Report. Owing to the poor quality of the samples, however, the experimental results were not successful. Failure was caused by too loose a control over the gold diffusion process that is needed for attaching leads to the junction. It seems that some of the gold diffused close enough to the junction region as to produce a poor reverse bias characteristic, so that a field high enough to effect a measurable shift in the absorption edge could not be maintained. Further efforts are being made to fabricate samples in which the diffusion depth of the gold is not so great.

1.02.07.2 Low Level, Near Infrared Detector

One of the problems in developing an electro-optical system is the design of a fairly inexpensive circuit for detecting low level light signals. Such circuits exist, but are not suitable for our purposes because either they must operate at low temperatures or, as in the case of the photomultiplier, they are too slow. The circuit shown in Figure 1 responds to a low level signal (7 volts output change for 0.4 μ watt input change) with an acceptable noise level. The SD100 photo-diode has a sensitivity of 0.25 μA/μW and an active area of about 0.073 cm^2. Its rise time is 4 ns into a 50 ohm load. The circuit is simply a Darlington amplifier driven by a grounded base transistor which provides the low impedance load for the photo-diode. Figure 2 shows the measured static characteristic of the circuit, which is seen to be linear in the range of interest. Noise, including thermal drift, is 50 mV at the output, for dark input. The spectral range of the detector is limited by the SD100 to 0.7 - 1.1 μ.

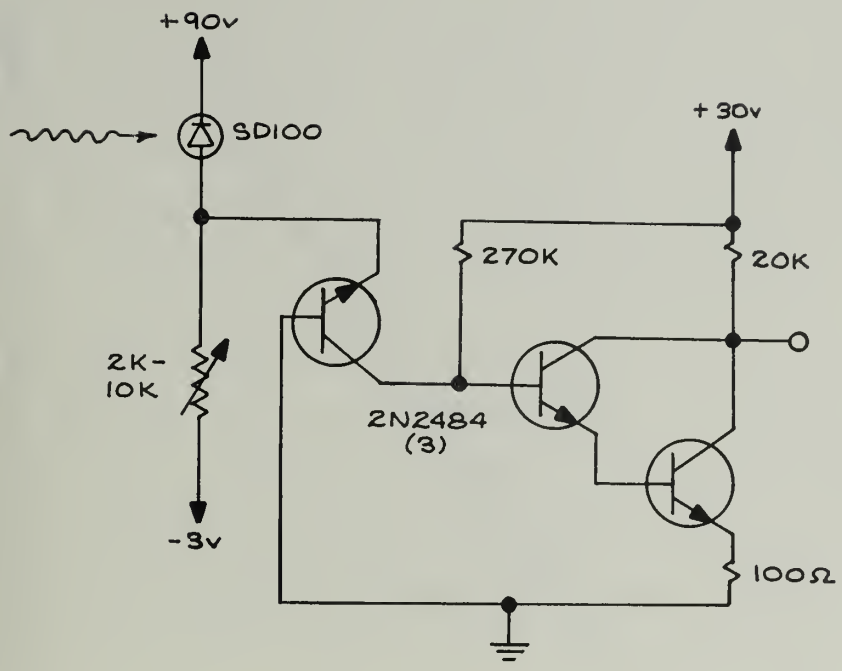


Figure 1. Fast Photodetector

1.02.14 Experiments With the Optical Differential Amplifier

1.02.14.1 Optical Differential Amplifier

Work has continued on the Optical Differential Amplifier to improve its stability characteristics and extend its usefulness. Light shields were constructed for the photo transistors so that fiber-optic light guides could be used at the input. The light guides attenuate the input signal slightly, but are very convenient for experimental purposes. Several experiments have been considered in which the amplifier would be very useful.

One such experiment is the measurement of near infrared absorption coefficients of semiconductor crystals. In particular, a comparison of the absorptive characteristics due to a pulsed ruby laser with those due to steady-state infrared might be of interest. The laser output consists of many pulsations with very small rise times. The reaction of crystals to these pulsations might be interesting.

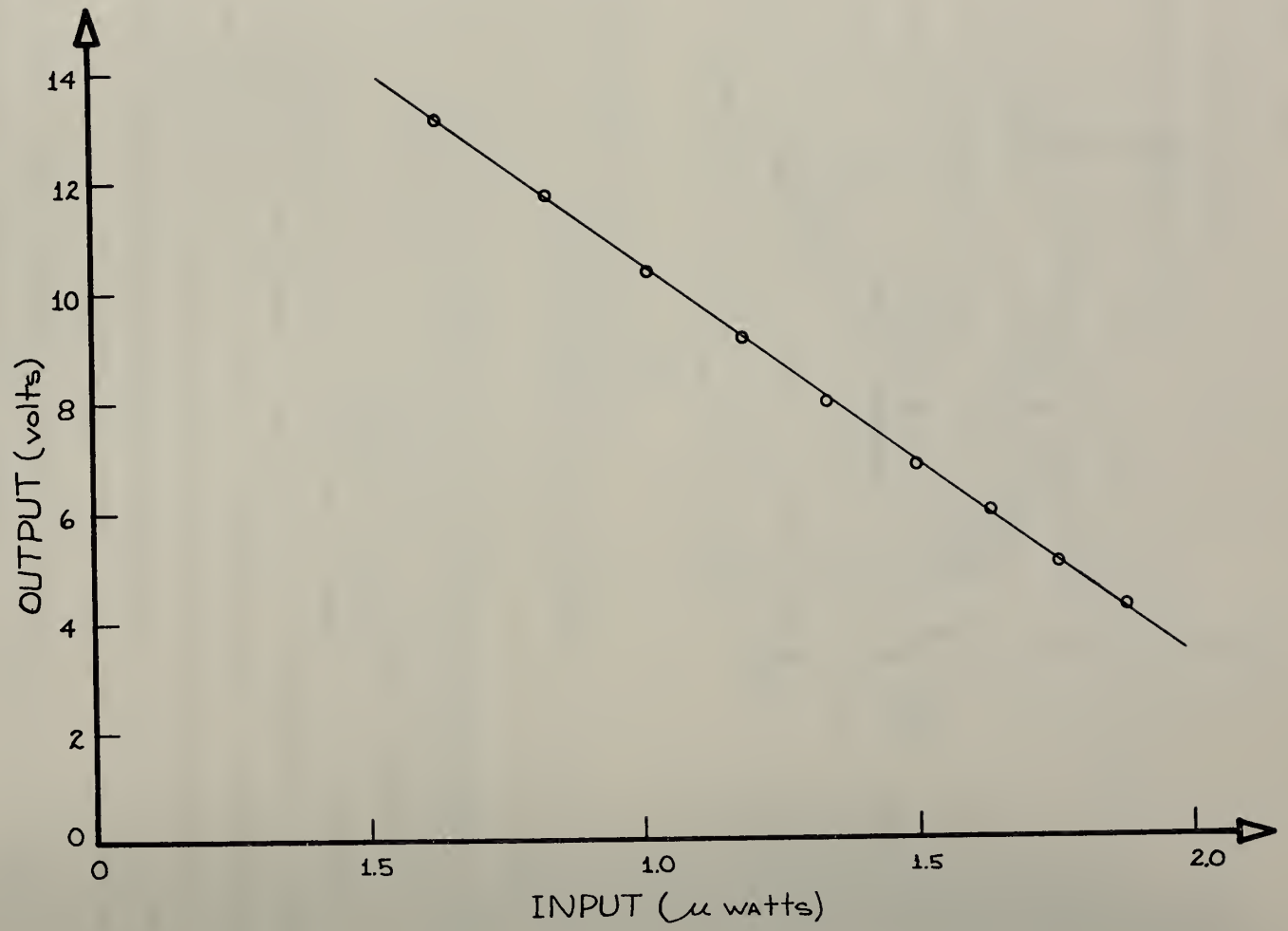


Figure 2. Response of Photodetector

A second use for the optical differential amplifier would be the preparation of incandescent sources for other experiments. The wave length distribution of the output from an incandescent source is a function of the temperature of the wire filament; varying the power input to the lamp changes its spectral output. So, if one should desire a particular wavelength from a source to be maximized relative to, for example, the third harmonic, one need merely observe the source through the two appropriate filters with the differential inputs, and then vary the power input to produce a maximum amplifier output.

At present the amplifier is being used in still a different manner. A pulsed ruby laser will be viewed through a diffraction grating or a pair of interference slits. The relative intensities of the interference maxima and minima are to be measured. The fiber-optic inputs will be used and measurements will be taken for several different gratings and slit spacings. There seem to be some possibilities of performing logic with such light patterns.

1.03 Random Sequence Coding (Noise Computer)

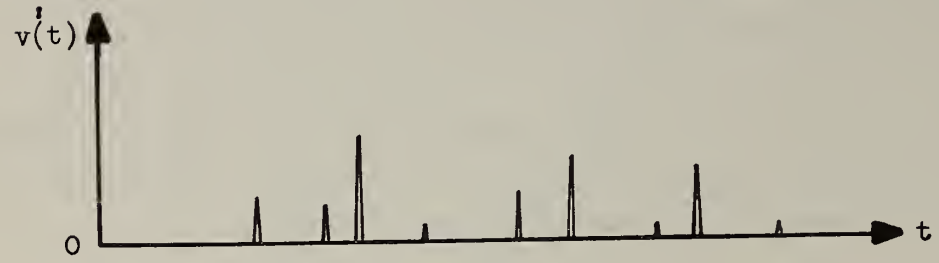
A method of controlling the average frequency of a random pulse sequence by amplitude discrimination of random amplitude noise.

1.03.01.1 Principle

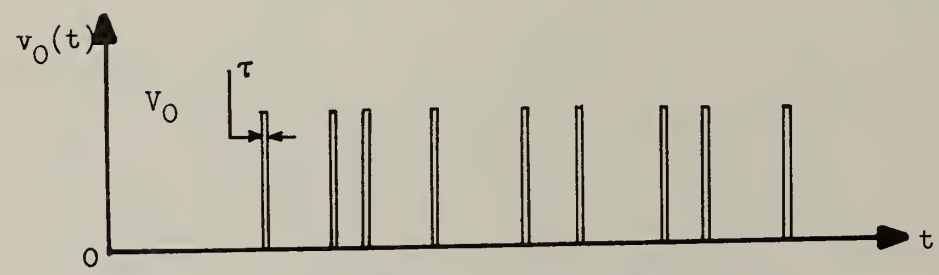
Suppose that we have a noise voltage as shown in Figure 1 (a). The amplitude and the spacing change at random with time. If those pulses whose amplitudes are higher than a particular value of voltage, $V_d (\geq 0)$, are selected, then a new sequence of noise pulses is obtained. This is shown in Figure 1 (b). This sequence of pulses with various amplitudes and widths is now shaped, so that each pulse has the standard size as shown in Figure 1 (c), the amplitude and the width being V_0 and τ, respectively. The pulse sequence obtained in this way is obviously a random pulse sequence, since the amplitude and the spacing of the original noise change at random with time.

Since the average number of pulses per unit time, i.e., the average frequency of the pulse sequence, is determined by the average frequency of occurrence of the noise pulses whose amplitudes are higher than V_d, it is a function of the discrimination level, V_d. As V_d is lowered the number of pulses picked up increases and therefore the average frequency of the random pulse sequence increases.

(a) Noise voltage



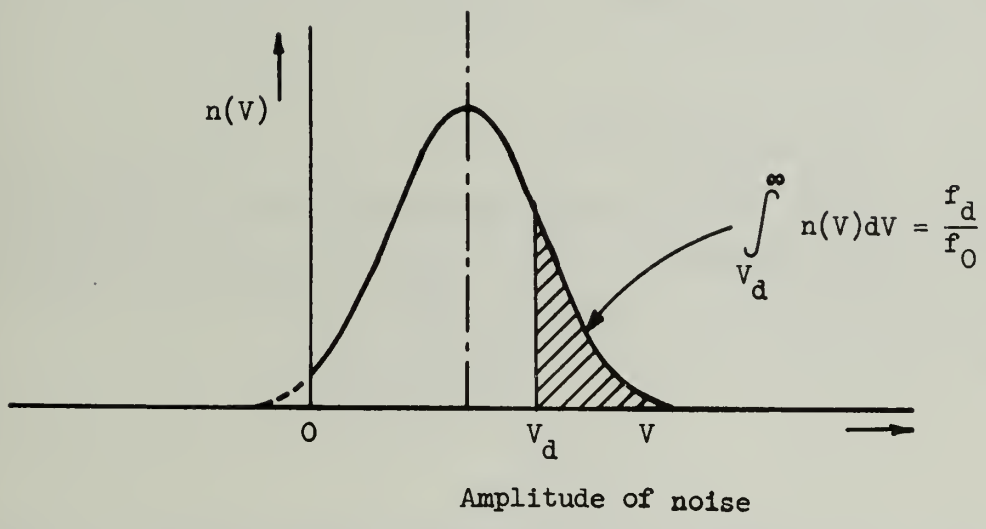
(b) Noise obtained by amplitude discrimination of (a)



(c) Random pulse sequence obtained by standardizing the noise of (b)

Figure 1. Process of Generation of a Random Pulse Sequence Whose Average Frequency is Controlled by the Amplitude Discrimination Level.

It is reasonable to assume the amplitude distribution of the original noise to be the normal distribution, i.e., the probability density function of the amplitude is bell shaped, as shown in Figure 2.



n(V): Probability that the amplitude is between V and V + dV.

Figure 2. Assumed Probability Density Function, n(v), for the Random Amplitude of the Noise.

By discriminating the amplitude with V_d all the pulses whose amplitudes are higher than V_d are converted to the standardized pulses. Thus the average frequency of such a random pulse sequence for any positive V_d is equal to the average frequency of the random pulse sequence for $V_d = 0$ times the integral of $n(v)$ from V_d to ∞, i.e.,

$$f_d = f_0 \int_{V_d}^{\infty} n(v)\, dV \qquad \text{(Eq. 1)}$$

where f_d = average frequency of the random pulse sequence for any positive V_d

f_0 = average frequency of the same for $V_d = 0$

V_d = discrimination level

or

$$\frac{f_d}{f_0} = \int_{V_d}^{\infty} n(v)\, dV = \text{shaded area in Figure 2} \qquad \text{(Eq. 2)}$$

Then for the relation between V_d and f_d we have an inverted S-shaped curve as shown in Figure 3.

1.03.01.2 Experimental Set-up

A noise diode is used as the original noise source. The noise voltage of the diode is a negative saw-tooth wave. This is put through R-C high pass filters and amplifiers, in order to produce a noise pulse sequence with amplitude large enough to be discriminated easily.

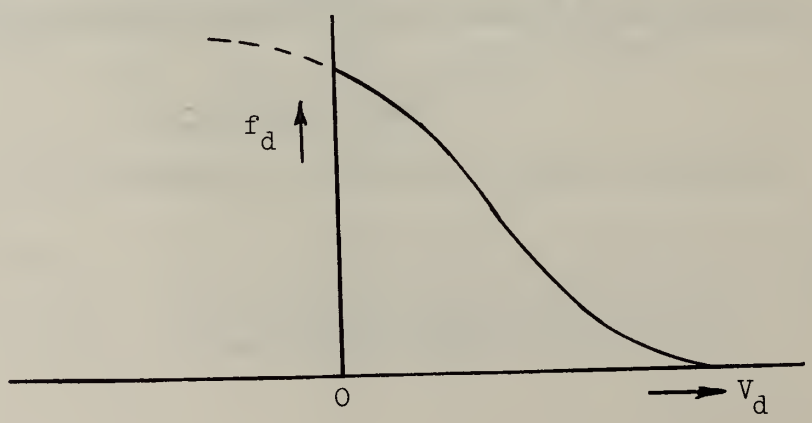


Figure 3. Average Frequency of the Random Pulse Sequence as a Function of the Discrimination Level for the Assumed Probability Density Function, $n(v)$.

As the amplitude discriminator a differential switching amplifier is used. The output voltage of the discriminator triggers the square-pulse-shaping circuits which consist of a one-shot multivibrator and an amplifier.

To take the average frequency of the pulse sequence a D'Arsonval-type voltmeter is used. It is easy to see that the average voltage of the pulse sequence is proportional to the average frequency of the pulse sequence, for each pulse is standardized. Let

f = average frequency of the pulse sequence

V_O = voltage height of the pulse

V_A = average voltage of the pulse sequence which can be read on the D'Arsonval-type voltmeter.

then

$$V_A = \tau V_O f \qquad \text{(Eq. 3)}$$

or

$$f = \frac{V_A}{\tau V_O} \qquad \text{(Eq. 4)}$$

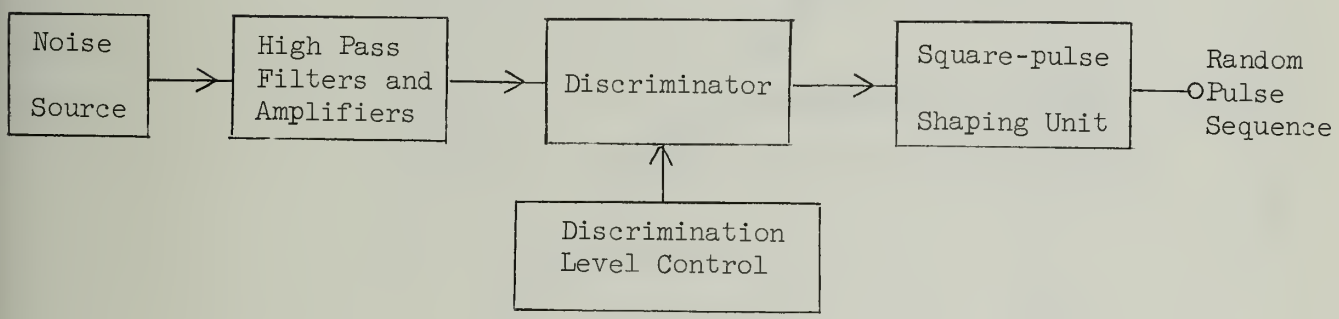


Figure 4. Block Diagram of the Experimental Setup

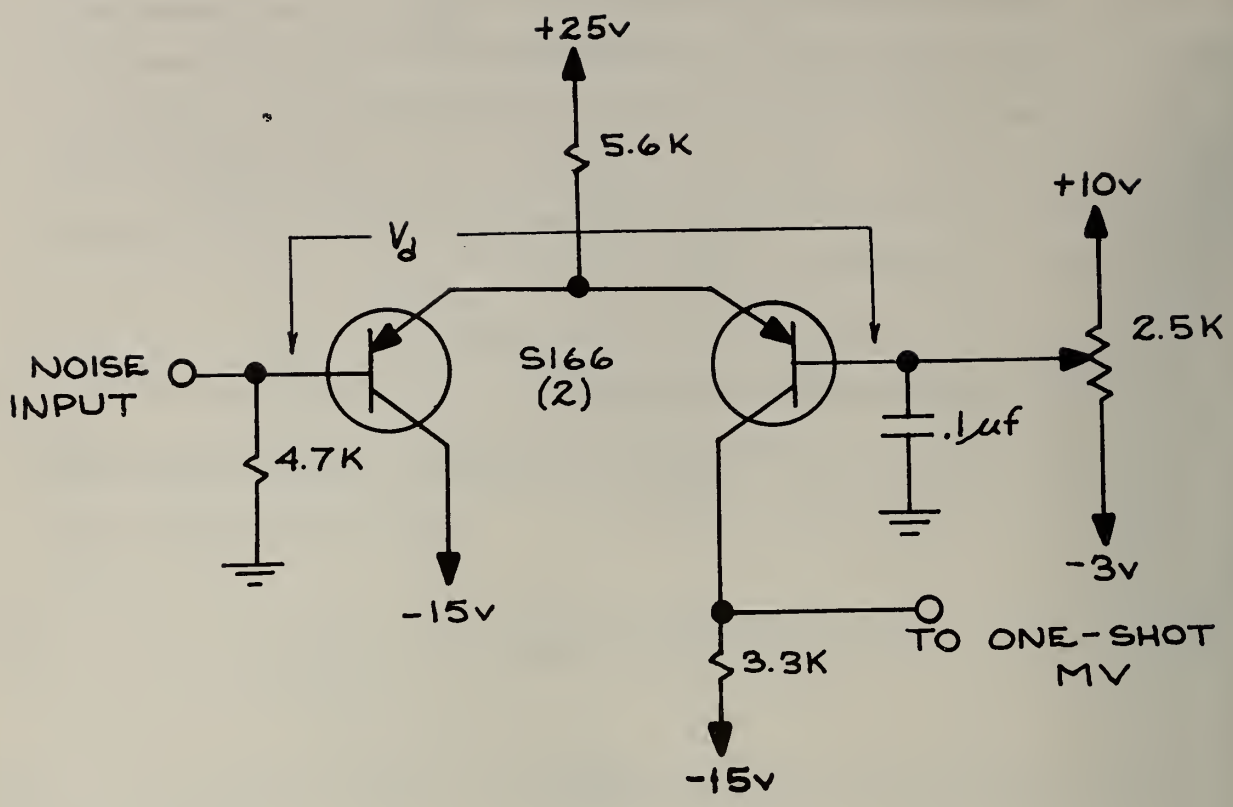


Figure 5. Discrimination Level Control

1.03.01.3 Results of Experiments

By measurements on the oscilloscope

$$\tau = 0.62 \text{ μsec}$$

$$V_0 = 16 \text{ volt}$$

then

$$f = \frac{V_A}{0.62 \times 16} \text{ mc/s} \cong 1.01\ V_A \text{ kc/s} \qquad \text{(Eq. 5)}$$

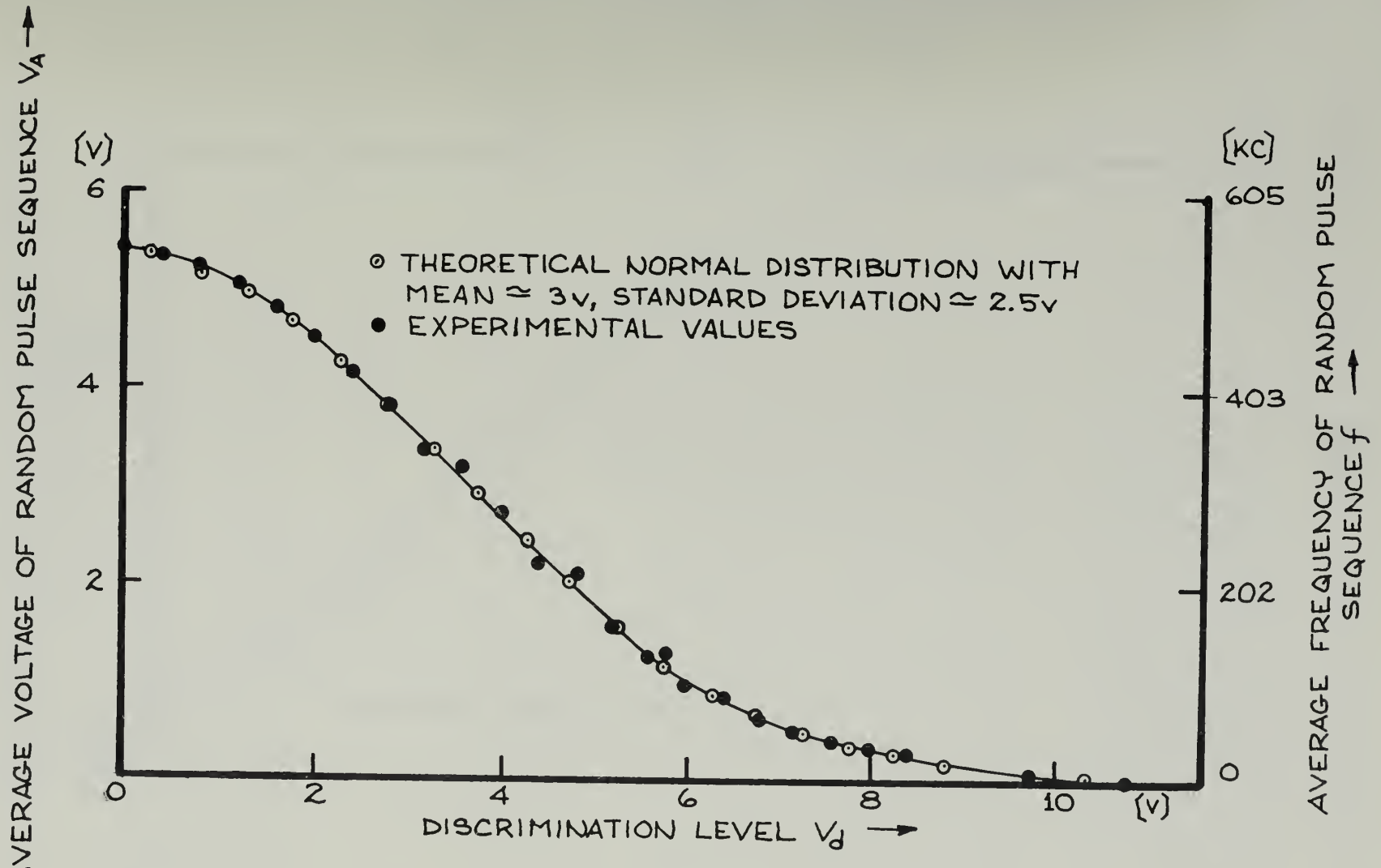


Figure 6. Comparison of Theoretical and Experimental Distribution

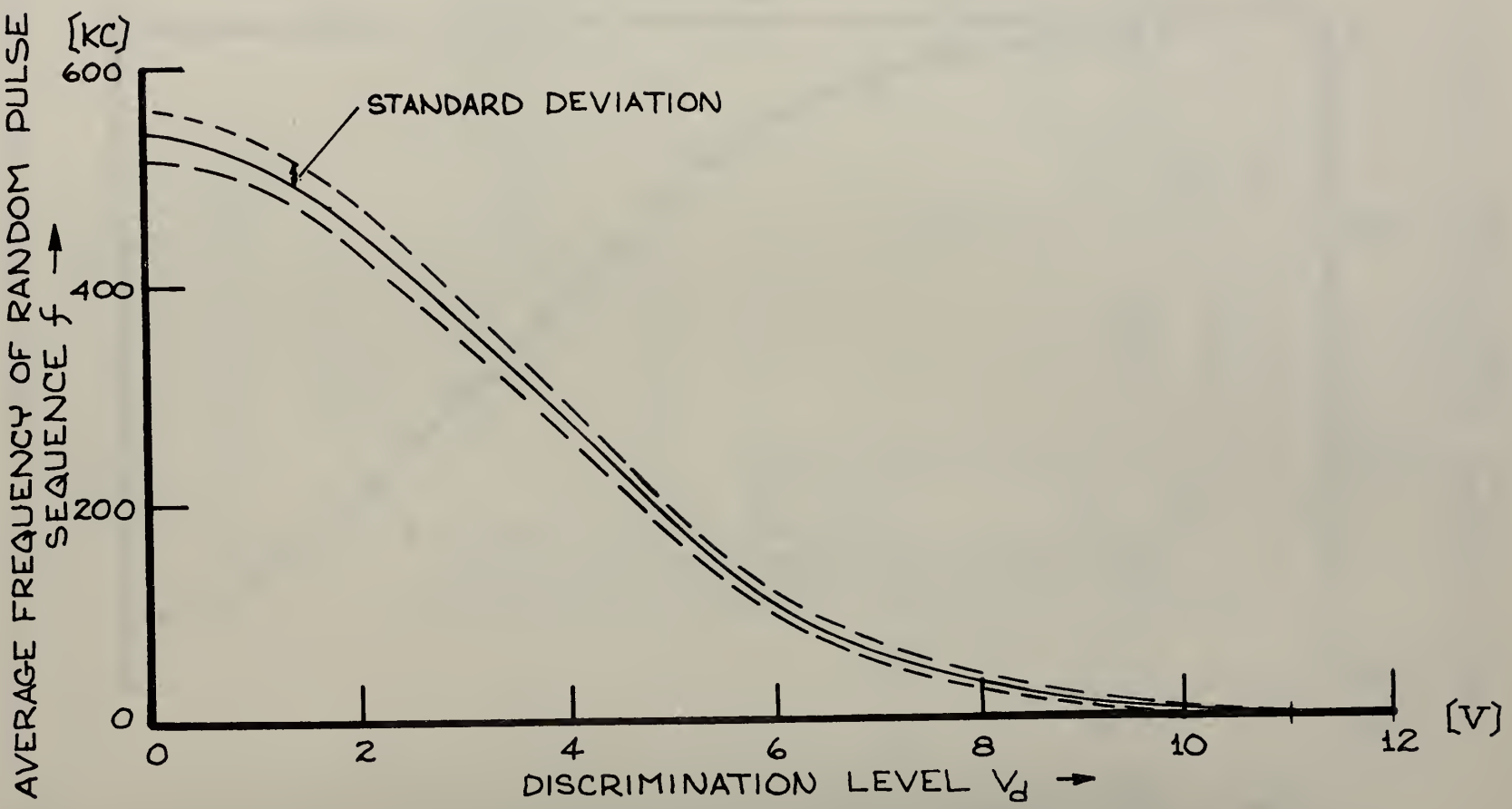


Figure 7. Theoretical Standard Deviation

This numerical value was checked by triggering the one-shot multivibrator with 250 kc-periodic pulses.

Figure 6 shows the V_d - V_A characteristic. The frequency scale is also indicated by using Eq. 5. The magnitude of the slope of this curve gives the amplitude distribution curve, n(v). At V_d = 10 volt, the slope is practically zero, indicating that there are hardly any 10 volt pulses. At V_d = 0 v the slope is finite and therefore the probability of finding very small pulses is not zero.

The normal distribution whose mean and standard deviation are adjusted so that it fits to the measured curve best is also plotted in the same figure. The comparison reveals that our assumption of the normal distribution for the amplitude of the noise is valid. However, since the probability of finding a very small amplitude is not zero and a negative amplitude is not possible, the probability density function can not fit exactly to the normal distribution. This is indicated in Figure 7. The theoretical normal distribution extends to negative values of amplitude as indicated by the dotted line. Namely, the actual amplitude distribution is a part of the normal distribution. Therefore the mean and the standard deviation for the actual amplitude distribution are not the same as for the normal distribution.

The curve in Figure 7 gives only the average frequency for given V_d. Since the frequency is distributed according to the Poisson distribution, the standard deviation may be obtained from the mean readily, i.e., for the Poisson distribution

$$\text{standard deviation} = \sqrt{\text{mean}} \qquad \text{(Eq. 6)}$$

For high values of mean, e.g., above ten, the Poisson distribution is well approximated by the normal distribution with the same mean and standard deviation. As the average frequency for any V_d is well above 10 cps in our measurements, the approximation by the normal distribution is valid. To show how widely the frequency of the random pulse sequence spreads, the standard deviation obtained from the mean is plotted in Figure 7.

1.04 Film Scanner

1.04.04.1 Description

The Film Scanner is an associative memory device for scanning a high contrast, black and white, 16 mm film in its passage through a Kodak "Industrialist" projector. The scanner decides in one operation whether or not a given set of "tag" digits is located on a film frame. If so, the entire word (called the tag word) is retrieved and the film is stopped when the tag word frame is in front of the projector light.

1.04.04.2 Operation

Each frame contains an eight bit word, denoted by $x_i \equiv x_{i0}\, x_{i1}\, x_{i2}\, x_{i3}\, x_{i4}\, x_{i5}\, x_{i6}\, x_{i7}$, its complement $\overline{x_i}$ and a strobe bit, as shown in Figure 1, ones being transparent and zeros opaque. The film passes between sets of light fibers, as shown in Figure 2. Lamps L_j and $\overline{L_j}$ ($j = 0, 1, \ldots, 7$) are set manually to indicate the tag digits in the following way. If the j'th digit of the tag is to be 1(0), L_j is turned on (off) and $\overline{L_j}$ is turned off (on). Lamps which correspond to unspecified digits, i.e., those not included in the tag, are left off. Then, when the i'th frame is aligned in the scanner, the output S_i of the OR circuit in Figure 2 is given by

$$S_i = \bigvee_{\substack{\text{tag} \\ \text{positions}}} (x_{ij} \oplus L_j) = \begin{cases} 0 \text{ if } x_i \text{ is a tag word} \\ 1 \text{ otherwise} \end{cases}$$

If $S_i = 1$, no action is taken; but if $S_i = 0$, this fact is stored by a control and two things happen. First, as x_i passes by the reading fibers, which are illuminated by the eight, continuously on lamps R_j (Figure 2), it is gated into a display register. Second, when the frame containing x_i reaches the projection light, the film is stopped so that the information can be displayed on a screen.

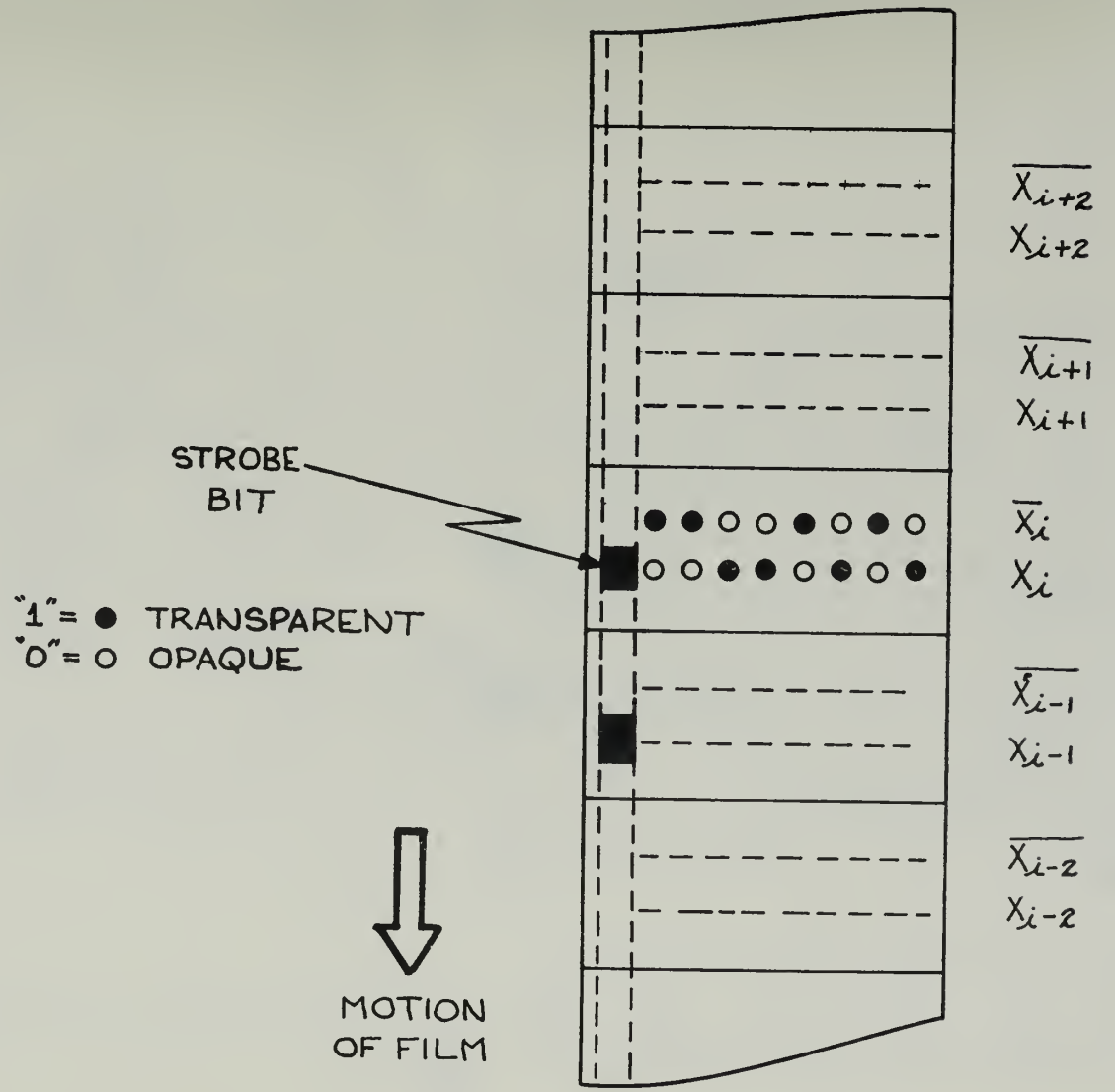


Figure 1. Layout of Information on Film for Scanner

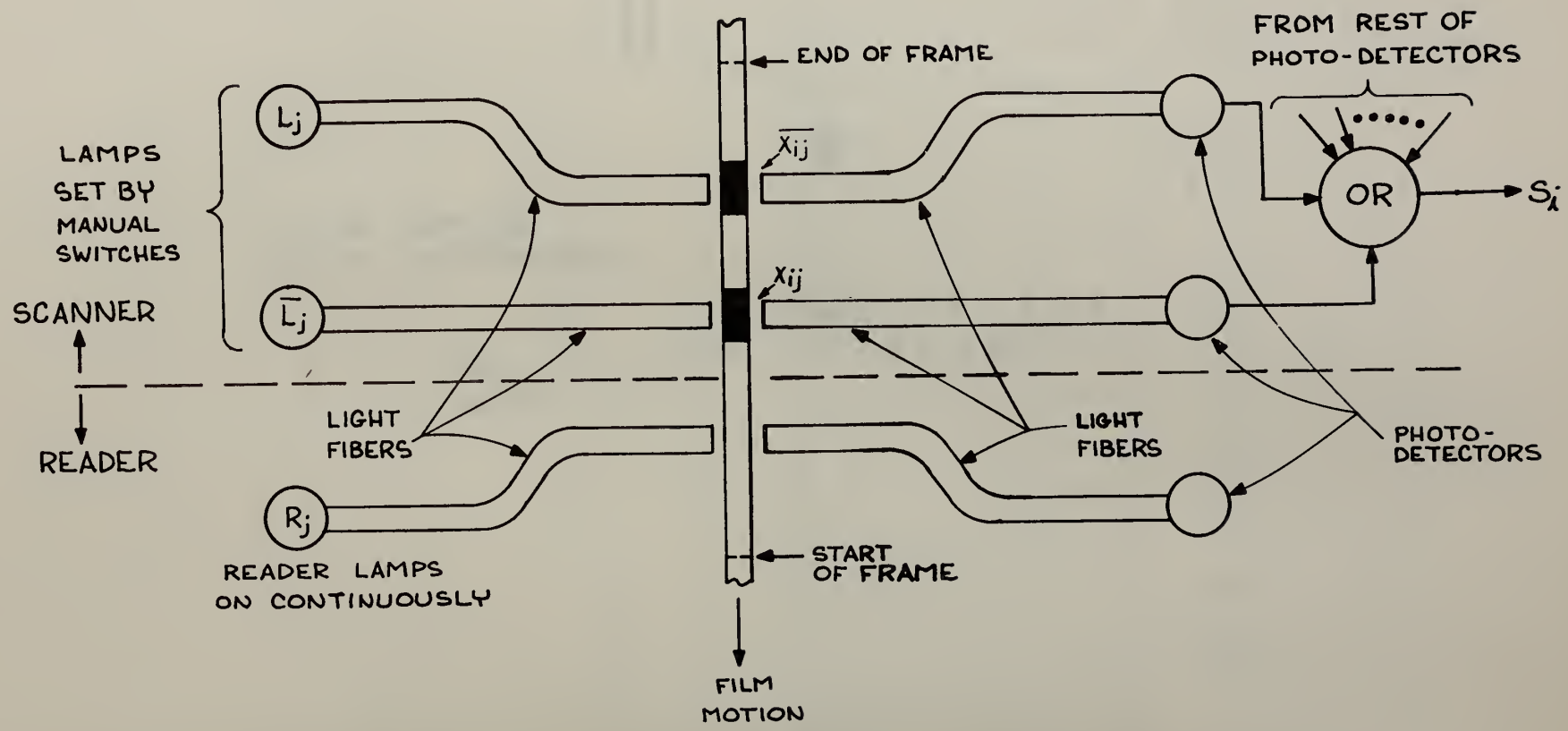


Figure 2. Fiber Optics of Scanner

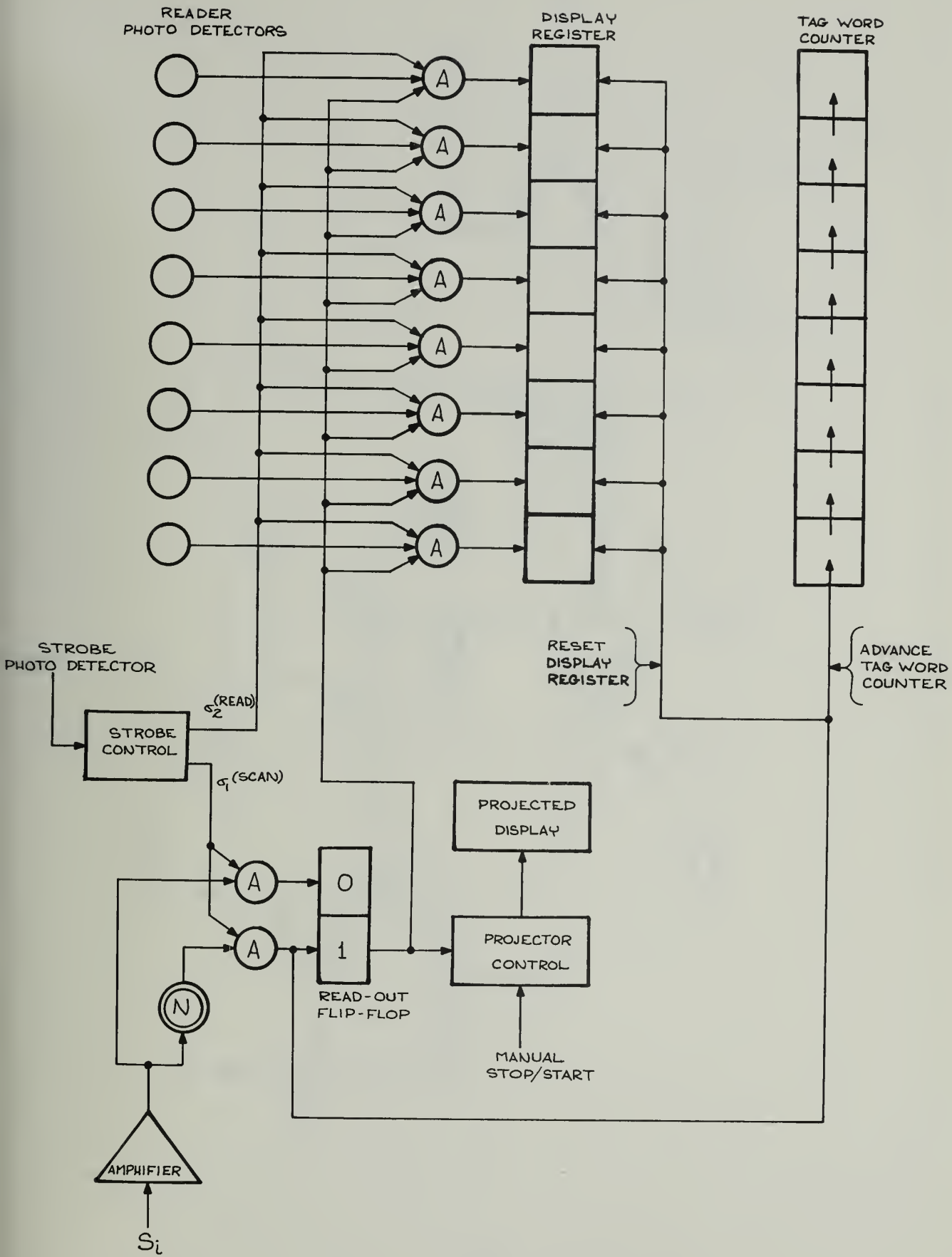


Figure 3. Logic of Scanner

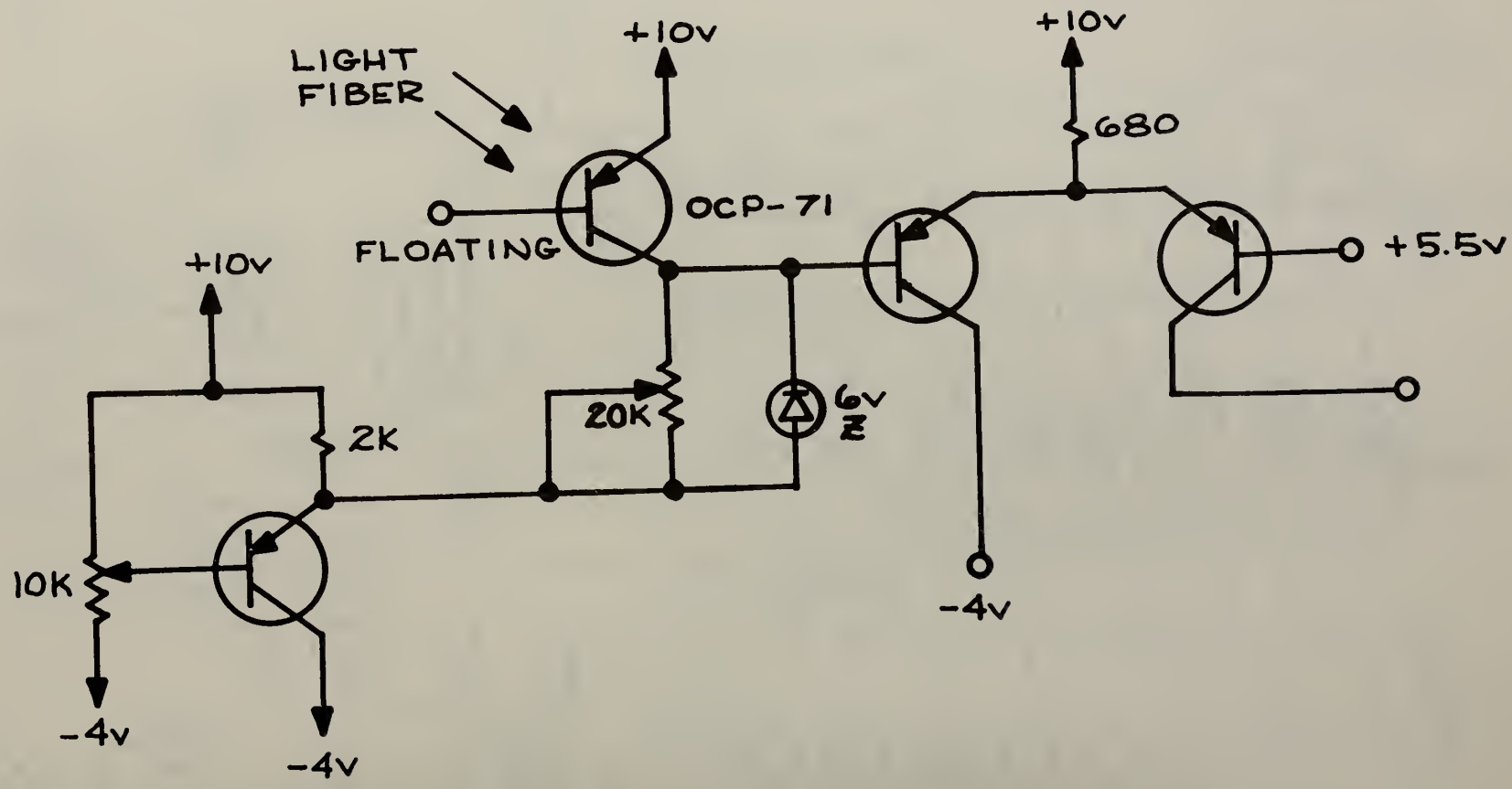


Figure 4. Photodetector for Scanner

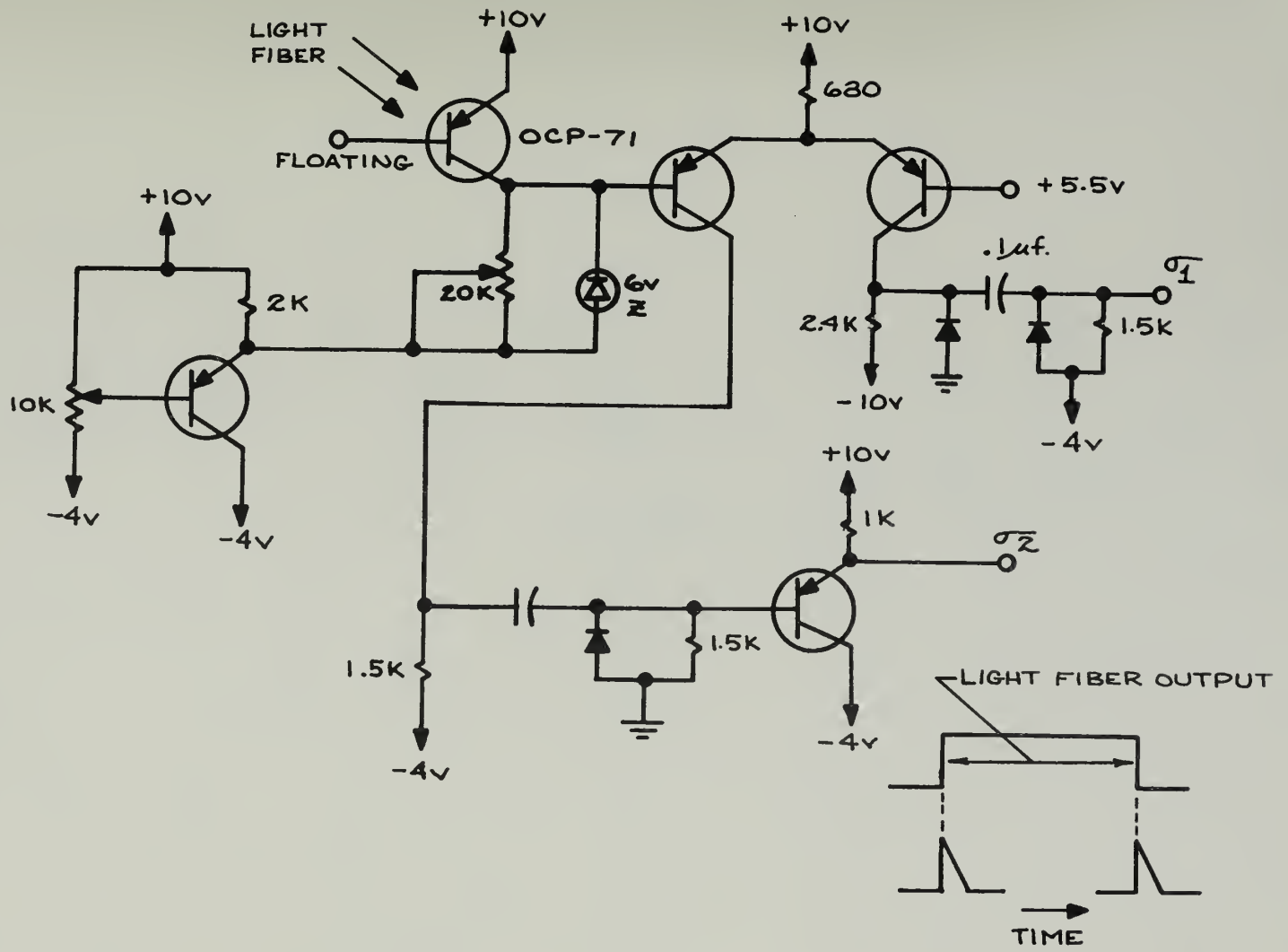


Figure 5. Strobe Control Circuit for Scanner

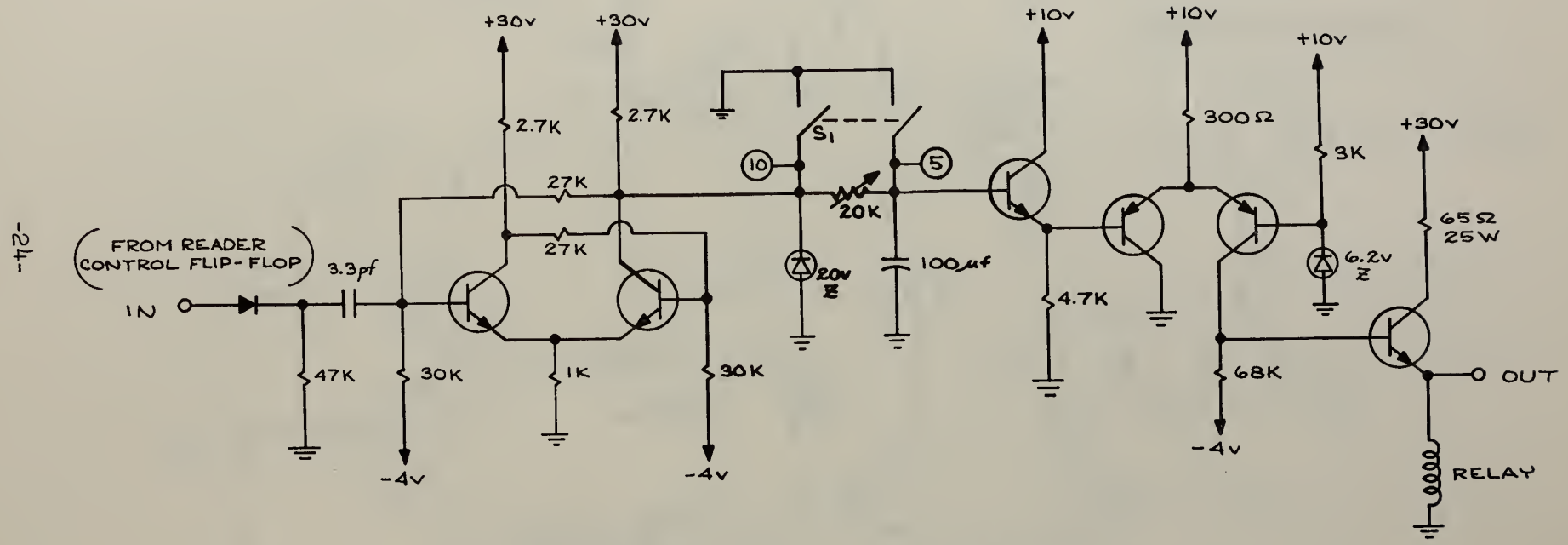


Figure 6. Time Delay Circuit for Scanner

1.04.04.3 Control

The strobe bit on each film frame is a rectangular, transparent spot of such dimensions and so positioned that when its photodetector switches from dark to light x_i and $\overline{x_i}$ are being scanned, and when the photodetector switches from light to dark x_i is in position for being read. The output of this photodetector is differentiated and shaped by the Strobe Control (Figure 3), into two pulses: σ_1, for strobing the scan signal S_i, and σ_2, for gating x_i into the Display Register. The Read-out flipflop is set by the condition (which also resets the Display Register and advances the Tag Word Counter) $\overline{S}_i \cdot \sigma_1$ and its output, together with σ_2, gates x_i into the Display Register. This output also triggers the Projector Control which (after a fixed time delay) stops the film when x_i is in front of the projector light. The Read-out flipflop is reset by the condition $S_i \cdot \sigma_1$, i.e., by the next word which is not a tag word.

1.04.04.4 Circuits

OCP-71 transistors are used in the photodetector circuits (Figure 4) and also in the Strobe Control Circuit (Figure 5). The time delay circuit for Projector Control is shown in Figure 6.

1.11 Photochromic Storage

1.11.13.1 Proposal

Several organic compounds are known to undergo reversible color changes when exposed to light of certain wave lengths. In general the light causes the material to become darker with increasing exposure, while removal of the source allows the material to relax back to its original state.

It has been proposed that this photochromic effect is not a linear function of incident light energy but instead, there is a threshold at which a rapid change takes place. The purpose of the Photochromic Storage project is to perform measurements on various photochromic materials to determine if the threshold exists and, if so, to what amount. Assuming the threshold is found, it is then proposed to build an experimental coincident-light memory using the photochromic material as a storage medium.

1.11.13.2 Initial Problems

Of the known photochromic materials, many are activated only by ultraviolet light (below 4000 Angstroms), which is unfortunate since most types of glass (light conducting fibers, windows on phototransistors, etc.) have a very low transmission coefficient in the U. V. region. The problem has been to locate photochromic materials and glass compounds that have mutually useful ranges.

The second problem is sources of supply. To date, only three sources of photochromic materials have been located and of these, one produces only a liquid form which, though useful for threshold experiments, is unsuitable for a memory.

The third problem is the measurement of U. V. light using photo-transistors or photodiodes. Though measurements of this type are not expected the possibility cannot be excluded.

2. HARDWARE SYSTEMS RESEARCH

(Supported in part by the Atomic Energy Commission under Contract No. AT(11-1)-1469)

Summary

Detailed proposals for Artrix System are given by John Esch, William Kubitz, Peter Oberbeck and David Rollenhagen. The purpose of the system is to enable a person equipped only with a light pen and control buttons to draw points, lines and curves on a flicker-free display panel.

The Pattern Transform Analysis project (Douglas Sand) is an investigation of the possibilities of purely optical processing of pictures, making use of the invariance of the Fourier Transform (as scanned by annular photocells) to translation and rotation.

2.10 The Artrix System

2.10.08.1 General

The Artrix System, as here proposed, is to be capable of displaying and storing simple forms of artwork such as points, line drawings and low-complexity geometric curves on a flicker-free display panel. In addition, the system is to perform certain picture processing functions on the points and curves displayed.

The display, picture processing and storage functions are to be achieved without incorporating a large general purpose digital computer. Thus the cost of the system will be low relative to that of similar systems employing such computers.

The system is to be basically analog in nature. A digital output will be provided, however, for final storage of the display in a digital computer, if desired.

The basic system diagram, comprising the display, the pen, the control, the processing unit and the memory, is shown in Figure 1.

The display unit serves two related functions. It displays the information in the memory and serves as the surface on which the user can write, specify points, on draw lines. The pen is for writing on selecting points on

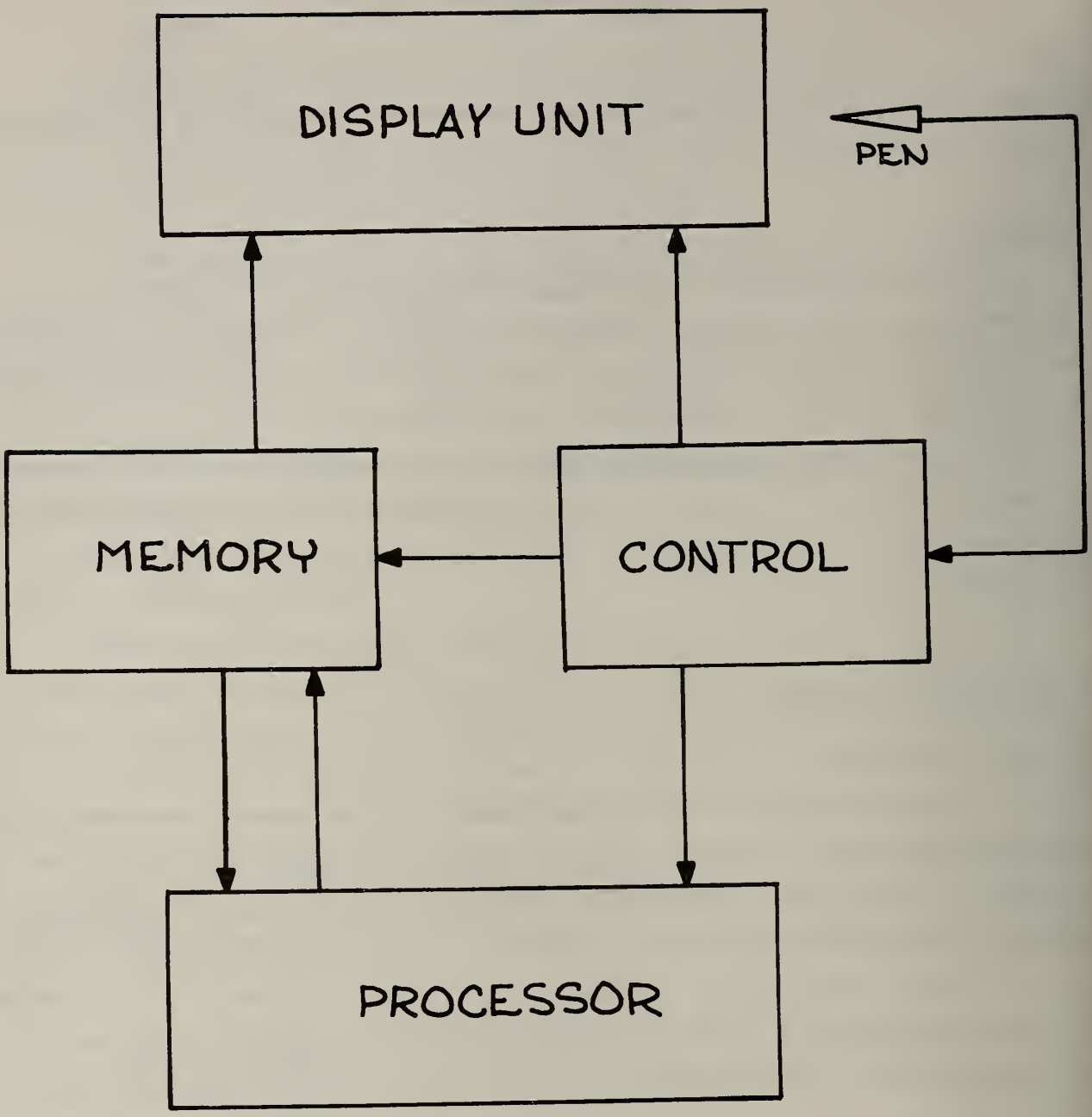


Figure 1. Basic Artrix Block Diagram

the display which are to be stored, erased or processed. The resolution of the pen will be adjustable for intercepting a large or small field on the display (corresponding to a broad or fine pen tip). The control determines which one of the following functions is to be performed in the system: reading, writing, erasing, storing or processing the contents of the memory on display.

The processing unit is capable of generating lines and curves when cardinal points are indicated by the user (e.g., it can construct a straight line through two given points). The memory stores the points, lines and other geometrical information put on the display by the user, as well as information generated by the processor.

Color processing and a provision for shading are envisioned as later features of the system. In addition, operations of greater complexity eventually may be performed by the processor.

2.10.09.2 Typical Artrix System Operation

The block diagram of the Artrix System is shown in Figure 2. Suppose that the user first wishes to write three points, X, Y, and Z on the display. He points the pen (set at high resolution for a fine point) at the desired position for point X and presses button A labeled "create a point." A dot then appears at this location on the display, and this location is simultaneously stored in the point memory. After repeating this operation for points Y and Z, the user sees the three points before him on the display, and the corresponding locations are recorded in the memory.

Suppose now that the user wishes to have a straight line constructed through points X and Z. To do this he sets the pen at low resolution (the low resolution facilitates locating a point within the beam width of the pen), points the pen at point X on the display, and depresses button C labeled "read and store points." This transfers the location of point X to the memory in the block labeled "Calculation" in Figure 2. The user repeats this operation for point Z. He then depresses the button labeled "draw a straight line," (one of the row of buttons in the block labeled "Calculation" in Figure 2) and a straight line through points X and Z appears on the display. This line is simultaneously stored in the line memory, and the "Calculation" is cleared for the next operation.

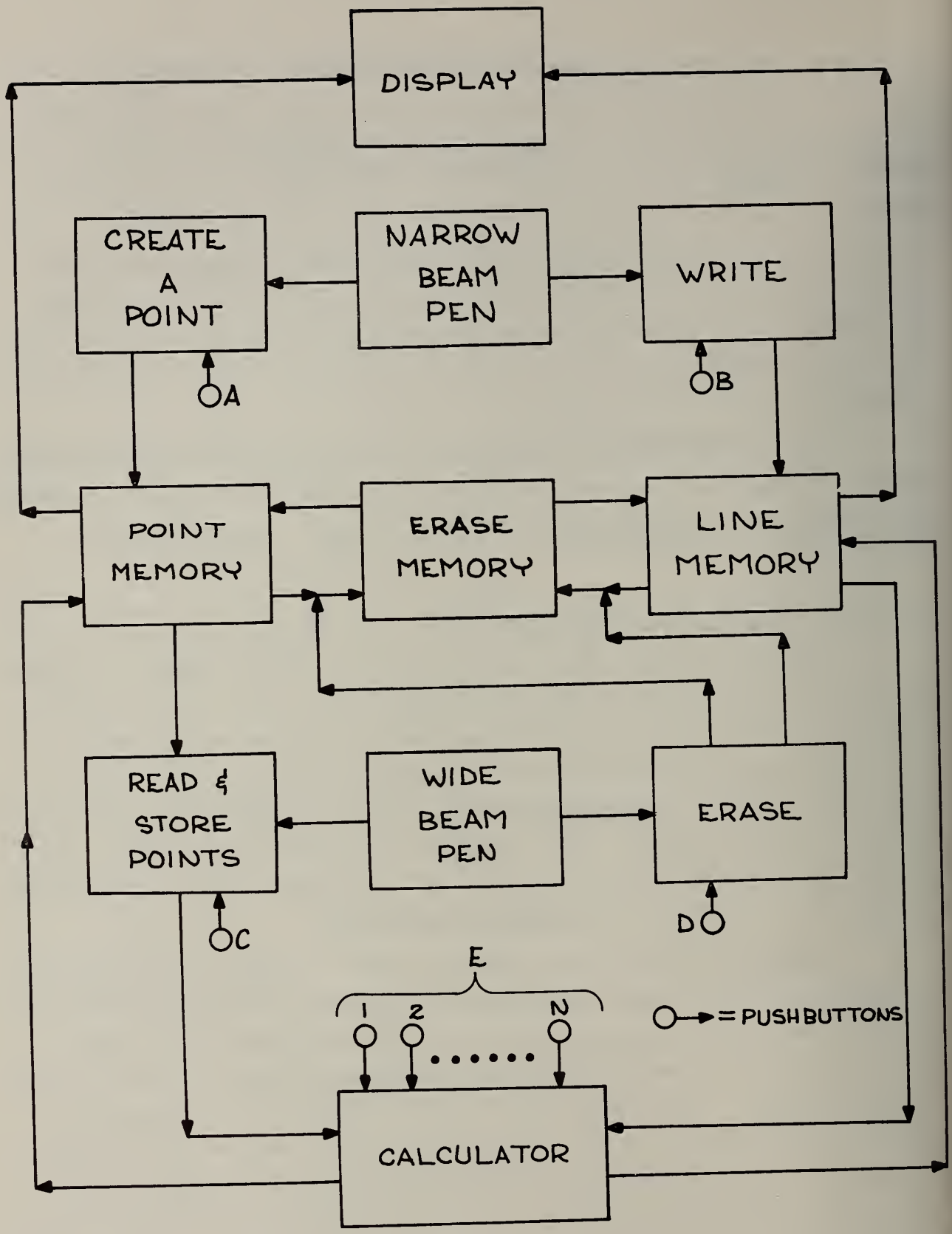


Figure 2. Detailed Artrix Diagram

The user next wishes to have a circle drawn with center at point X, passing through point Z, for example. He has been instructed that to have a circle drawn he must indicate, in order, the center and any point on the circumference. He points his pen (set at low resolution) at point X, presses button C labeled "read and store points," and then repeats this operation for point Z. These two points are now stored in the memory of the "Calculation." He then presses the button labeled "draw a circle," and a circle appears on the display centered at point X, passing through point Z. This circle is simultaneously stored in the line memory.

The user may indicate and store any number of points on lines in the point memory on line memory, respectively, which he may wish to use for further geometric constructions. For example, he may wish to indicate the point of intersection of two lines on curves for future reference. To accomplish this, the user simply points his pen (set at low resolution) in the vicinity of the intersection and presses button C labeled "read and store points." The "Calculation" unit automatically determines the exact point of intersection and stores the corresponding location in the point memory. The contents of the line on point memories may be displayed together or separately at any time, as desired.

The Artrix System may be used simply as a sketch pad, where the user draws a line sketch on the display and has the sketch stored in the line memory. Erasing is easily accomplished by setting the pen at low resolution, pressing the erase button D, and retracing with the pen the desired portion.

2.10.11.3 The Display

The display will be of standard television type, consisting of a cathode ray tube and the associated circuitry. Conventional displays have a vertical frequency of 60 fields per second with alternate fields interlaced giving thirty complete frames per second. The horizontal frequency is 15,750 cps giving 525 lines per frame. In order to provide a digitized output, each horizontal line must be subdivided. For a 525 by 525 matrix of discrete points each horizontal line must be quantized into 525 points. The corresponding sampling rate is approximately 8.5 megacycles.

Conventional television systems employ one of two different methods of interlacing the vertical and horizontal scans. One is the positive interlace, in which the horizontal scans are counted down to imitate the vertical scan. The other is the random interlace, where the horizontal scan frequency is controlled by a crystal oscillator independently of the vertical scan. In order to locate the scanning electric beam at any particular instant of time, a capability essential to the operation of the Artrix System, the positive interlace method must be used.

The display will show the contents of the memory by direct connection with the read mechanism in the memory unit. The display will also serve as the writing pad, but in fact the writing will be performed indirectly. That is, the light pen will sense the point on the display at which the pen is located and will cause a dot corresponding to this location to be written in the memory. When the dot appears in the memory, the read mechanism locates it and transmits this information to the display where it is viewed. Thus the user sees what he is writing (instantaneously as far as he is concerned), and his sketch is stored in the memory as he is writing. The pen will be a light sensitive device, and will sense its position on the display by detecting the scanning beam as it crosses the location of the pen.

2.10.11.4 The Memory

Since the system is to be analog in nature, a continuous storage medium is desired. Two possibilities are electro luminescent plates and storage tube devices. The latter appear more promising for the immediate future because of the advanced state of the art in storage tube design.

The read and write mechanism associated with the memory must fulfill three requirements. First, they must incorporate a mechanism capable of erasing selected portions of the memory. Second, the read and write mechanisms must be capable of functioning as fast as the rate of scan in the television display. Third, the read and write resolution must be better than the resolution of the display.

Several commercially available storage tubes appear particularly well-suited to the requirements of the Artrix System memory. Most types are for storage purposes only, and lack provision for reading out the stored information. Such types would require an external reading apparatus. Scan conversion storage tubes are available, however, with both write and read facilities. These tubes consist, essentially, of two cathode ray tubes mounted face to face, one tube for writing information on the storage surface, the other tube for scanning and reading out stored information.

2.10.05.4 The Processor

The object of this part of the Artrix System is the ability to perform, in an easy, quick and accurate way, the graphical constructions that are done more slowly by a draftsman using pencil, eraser, ruler and compasses. Thus, the essential features of the Processor would be the ability to:

1) create a point;
2) construct a straight line through two points;
3) construct a circle of given center and radius;
4) erase a given part of the drawing.

Among desirable features would be the construction of:

5) a straight line segment between two points;
6) an arc
7) a vertical or horizontal line through a given point.
8) the mid point of a line segment;
9) the intersection of two lines;
10) a given piecewise continuous curve.

The exact amounts of analog and/or digital circuitry that would make up the Processor have not yet been determined. On the one hand, an analog system would seem suitable for generating straight lines and circles; on the other, a small electronic digital calculator might be useful. These details together with estimates of hardware, speed of operation, interaction with the Memory and flexibility of design are currently being evaluated.

2.10.08.5 A Preliminary System

As a first step in the development of the memory and display sections of the Artrix System, the simple system shown in Figure 3 is being built. Here the display is a television monitor and the memory is a Memotron storage tube. This tube is only capable of writing the stored information on its screen, so that the television camera is for reading the stored information externally. The camera and monitor form a closed-circuit television system. The information stored in the memory is transmitted to the display on which the motion of the pen is traced out.

The Memotron tube is capable of writing at a rate of 150,000 inches per second on a useful screen diameter of four inches. A square inscribed in the useful screen area will be $2\sqrt{2}$ inches on a side, giving a line rate of

$$\frac{150,000}{2\sqrt{2}}$$

on 53,571 lines per second. This rate, compared with that of the television display, 31,500 lines per second, is more than adequate. The maximum resolution of the Memotron is 50 lines per inch, on $50 \times 2\sqrt{2} = 141$ lines total, as opposed to 525 lines of the television display. This results in approximately 3.7 television lines per memory line, and means a considerable loss in resolution of the stored information. As a first experiment, however, the use of the Memotron tube will provide a good indication of the capabilities of the Artrix System.

2.12 Pattern Transform Analysis

2.12.12.1 Spatial Transform Analysis

Optical systems can be used to produce spatial Fourier transforms of semitransparent patterns. A spatial transform is a representation of the spatial frequency composition of the original pattern. A spatial transform has several useful characteristics, such as invariance to a translation of the original pattern (under certain restrictions). Further operations on a spatial transform such as integration, can produce representations which are also invariant to rotation or magnification of the pattern. It may be possible to use these invariant pattern representations with suitable correlation techniques to classify various sets of patterns.

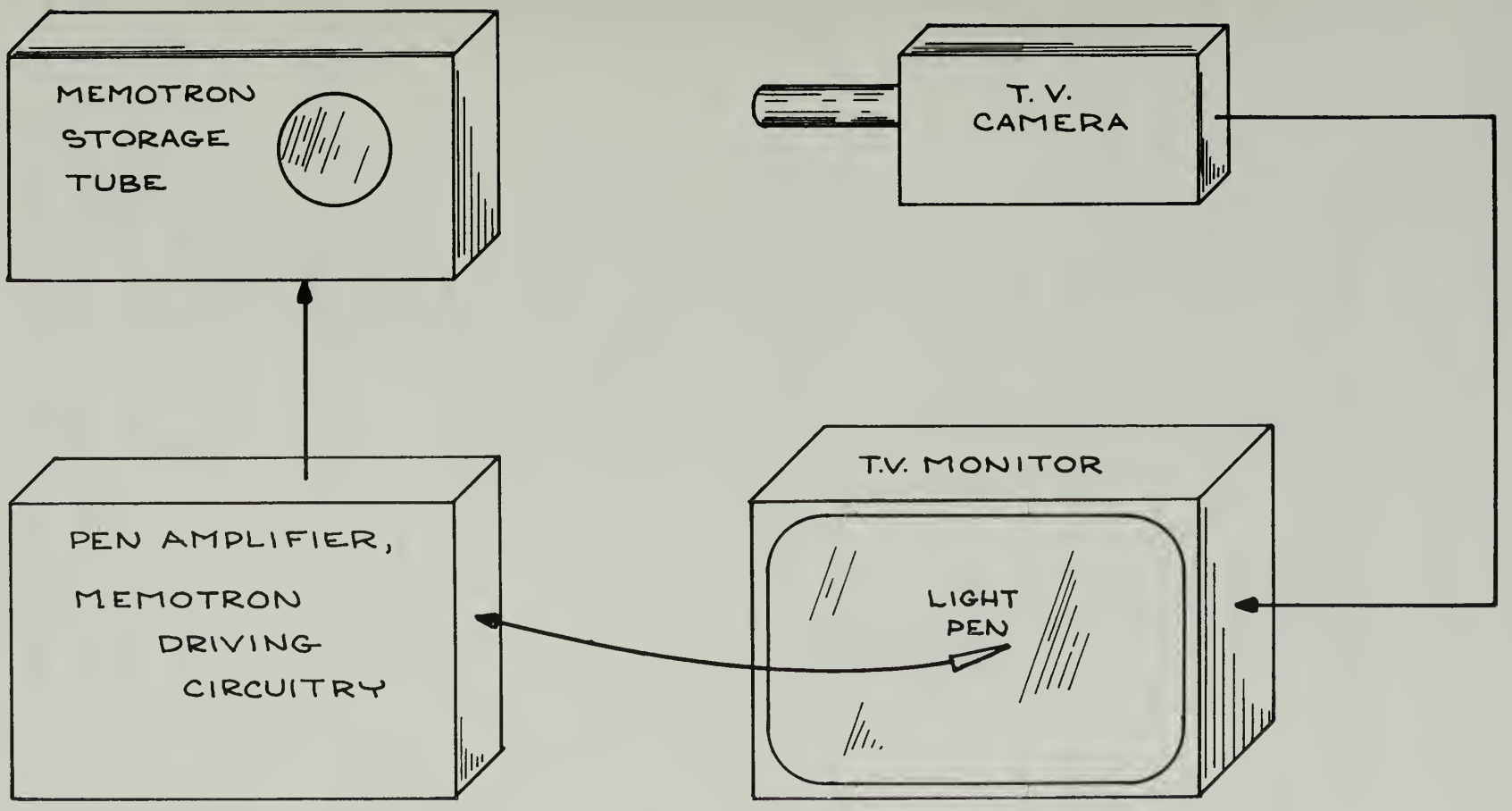


Figure 3. Preliminary System

Some aspects of spatial transforms are discussed here. Section 2.12.12.2 is a brief introduction to various concepts and properties of optical spatial transforms, and Section 2.12.12.3 develops an expression for the geometrical transfer function of a pair of one-dimensional apertures.

2.12.12.2 An Introduction to Optical Spatial Transforms

Light passing through a semitransparent object is distorted by diffraction. If the light before diffraction is a plane wave and if the diffracting object is a planar pattern we have the special case of Fraunhofer diffraction. The planar distribution of the Fraunhofer-diffracted light at an infinite distance from the pattern can be shown to be the spatial Fourier transform of the original pattern [1]. A simple lens, however, has an "optical transfer function" (essentially a low-pass spatial frequency filter) which distorts the original (unfocused) spatial Fourier transform [2]. The result is that a simple optical system can produce a physical representation of the spatial Fourier transform of a planar pattern.

A familiar example of a spatial transform is the Fraunhofer diffraction pattern of a fine, uniform grating (see Figure 1). The grating is composed of parallel strips separated by a distance d, and is centered on and normal to the optical axis of a simple lens of focal length f. A plane wave of monochromatic light of wave length λ, propagating in a direction parallel to the optical axis, is used to illuminate the grating. The pattern that appears in the conjugate focal plane of the lens consists of a bright spot at the optical center and a bright spot on each side of the center spot, separated by a distance $\sim f\lambda/d$. These side spots are the representation of the spatial frequency d (of unit cycles/mm, generally) which is the fundamental frequency of the grating pattern. The bright spot at the center represents the amplitude of the zero-frequency component (spatial average) of the grating pattern. These three bright spots then represent a first-order approximation of the spatial frequency distribution of the grating pattern.

The spatial transform produced by Fraunhofer diffraction and focused by a simple lens can be passed through a second lens to reconstruct the original pattern as an image (see Figure 1). This reconstructed image differs from the original pattern only in the distortions introduced by the optical transfer functions of the two lenses. Image reconstruction corresponds to the universe Fourier transform process [1].

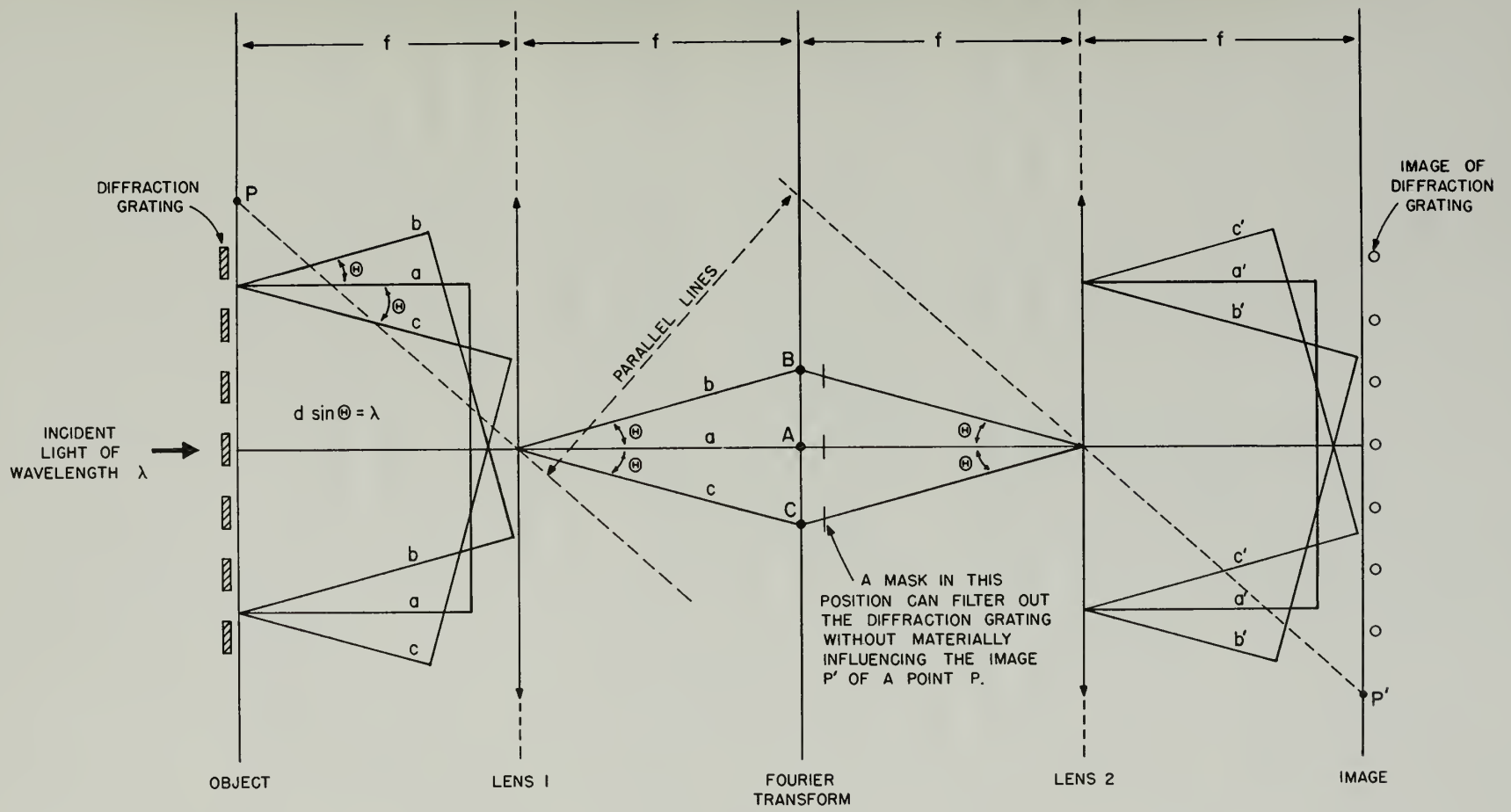


Figure 1. Principle of Fourier Transform Optics

In this image reconstruction process the two lenses have altered the frequency distribution of the original pattern. We could further alter this frequency distribution by inserting a "spatial filter" in the transform plane between the two lenses. For example, if we have a pattern corrupted by noise, we may be able to improve the signal-to-noise ratio by a suitable "matched spatial filter" [3]. Or we can improve the contrast of a photograph (by attenuating low spatial frequencies), suppress haze in a photograph (similar to improving the contrast), "refocus" a photograph which is out of focus, etc. [4].

Another approach is to ignore the inverse transform image reconstruction and consider only the spatial frequency distribution (the spatial transform) of the original pattern. Except for the distortion caused by the lens this spatial transform is simply another representation of the pattern. It may be possible to find frequency characteristics which are invariant for a given class of patterns and which can be used for pattern classification through, perhaps, a correlation process.

This second approach is of particular interest in the area of pattern classification because, with certain restrictions, the spatial transform of a pattern is essentially invariant to an (arbitrary) translation of the pattern in its plane or along the optical axis [5]. That is, the spatial transform does not require exact pattern registration.

However, the spatial transform is not invariant to either rotation or magnification of the pattern [5]. Pattern rotation produces a corresponding rotation of the spatial transform, and pattern magnification produces an inverse magnification of the spatial transform.

Additional operations can be performed on the spatial transform to introduce other invariance properties. For example, axial integration (by a set of annular "rings") will produce invariance to pattern rotation. Radial integration (by a set of rays) produces invariance to pattern magnification. It is clear that this type of operation results in additional invariance at the cost of a loss of information.

If the two integration operations are applied to the spatial transform in a parallel manner the result would be two translation-invariant identifiers for any given pattern. One of these identifiers would be rotation-invariant and the other would be magnification-invariant. Then it may be possible to develop correlation or other techniques which could use either or both of these identifiers for a useful pattern classification procedure.

2.12.12.3 An Exercise in the Geometry of Operations

One of the factors involved in the development of an optical transfer function for a lens is the effect of the finite areas (apertures) of the pattern and the lens. That is, a plane wave of light passing through the aperture in the pattern plane "sees" an opening in the lens plane distorted by a function of the relative size and separation of the two apertures and of the angle describing the direction of propagation of the light relative to the optical axis of the two planes. For simple apertures in both planes, this "projective" aperture is maximum in area for a propagation angle of zero and vanishes for angles greater than a maximum fixed by the geometry of the system.

To make the concept of this "projective" aperture more explicit, consider the combination of two one-dimensional simple apertures aligned in a plane (see Figure 2). The two apertures are parallel, centered, and separated by a normal distance z. The first aperture is of length $2R_1$ and has a "transfer function" which is

$$A_1(r_1) = u(R_1 - r_1)\, u(R_1 + r_1),$$

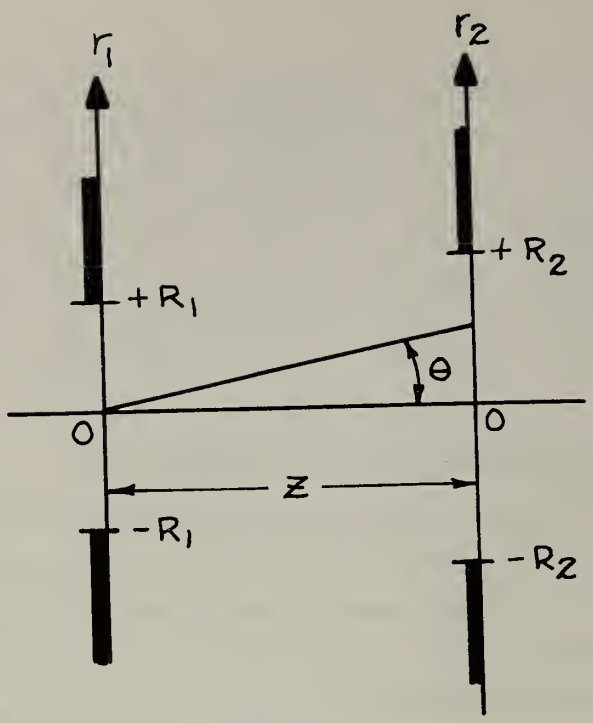


Figure 2. Geometry of Two One-Dimensional Apertures

where

$$u(r) = \begin{cases} 1 & \text{for } r \geq 0, \\ 0 & \text{for } r < 0. \end{cases}$$

The second aperture is of length $2R_2$ and has the transfer function

$$A_2(r_2) = u(R_2 - r_2)\ u\ (R_2 + r_2).$$

At a projection angle θ the relation between r_1 and r_2 is

$$r_2 = r_1 + z \tan \theta.$$

The combined apertures now have a transfer function which is

$$A_{12}(r_1, \theta) = A_1(r_1)\ A_2(r_2) = A_1(r_1)A_2(r_1 + z \tan\theta)$$

$$= u(R_1 - r_1)\ u\ (R_1 + r_1)\ u\ (R_2 - r_1 - z \tan\theta)\ u\ (r_2 + r_1 + z \tan\theta).$$

Thus light intersecting a point r_1 at an angle θ will be blocked if

$$|r_1| > R_1,$$

or if

$$|r_1 + z \tan\theta| > R_2.$$

The "amount of light" $A_{12}(\theta)$ which passes both apertures at an angle θ is found by integrating $A_{12}(r_1, \theta)$ with respect to r_1:

$$A_{12}(\theta) = \int A_{12}(r_1, \theta) dr_1$$

$$= \int_{-\infty}^{\infty} u(R_1 - r_1)\, u(R_1 + r_1)\, u(R_2 - r_1 - Z \tan\theta)\, u(R_2 + r_1 + z \tan\theta) dr_1$$

But

$$u(R_1 - |r_1|) = 0 \quad \text{for } |r_1| > R_1,$$

so

$$A_{12}(\theta) = \int_{-R_1}^{R_1} u(R_2 - r_1 - z \tan\theta)\, u(R_2 + r_1 + z \tan\theta)\, dr_1.$$

This integral is of the form

$$\int_a^b u(d - x)\, u(c + x)\, dx = u(g)g,$$

where

$$g = \min(b,d) - \max(a, -c),$$

so

$$A_{12}(\theta) = u[g(\theta]g(\theta),$$

where

$$g(\theta) = \min(R_1, R_2 - z\tan\theta) - \max(-R_1, -R_2 - z\tan\theta).$$

Let

$$\theta_g = \tan^{-1}\frac{R_2 - R_1}{z}.$$

Then

$$\min(R_1, R_2 - z\tan\theta) = \begin{cases} R_1 & \text{for } \theta \le \theta_g, \\ R_2 - \tan\theta & \text{for } \theta > \theta_g; \end{cases}$$

and

$$\max(-R_1, -R_2 - z\tan\theta) = \begin{cases} -R_1 & \text{for } \theta \ge -\theta_g, \\ -R_2 - z\tan\theta & \text{for } \theta < -\theta_g. \end{cases}$$

This gives

$$g(\theta) = \begin{cases} 2R_1 & \text{for } -\theta_g \le \theta \le \theta_g; \\ R_1 + R_2 - z\tan\theta & \text{for } -\theta_g \le \theta > \theta_g, \quad \text{so } \theta > \theta_g; \\ R_1 + R_2 + z\tan\theta & \text{for } -\theta_g > \theta \le \theta_g, \quad \text{so } \theta < -\theta_g; \\ 2R_2 & \text{for } -\theta_g > \theta > \theta_g. \end{cases}$$

Clearly the last case can only occur if $\theta_g \le 0$ for which $R_2 \le R_1$. We are also interested in a value of $\theta = \theta_0$ for which $g(\theta) = 0$:

$$g(\pm\theta_0) = R_1 + R_2 - z\tan|\theta_0| = 0$$

so

$$\theta_0 = \tan^{-1}\frac{R_1 + R_2}{z}.$$

The complete function $A_{12}(\theta)$ for $R_2 \geq R_1$ is then

$$A_{12}(\theta) = u[g(\theta)]g(\theta) = \begin{cases} 2R_1 & \text{for } |\theta| \leq \theta_g, \\ u(\theta_0 - \theta)\, u(\theta_0 + \theta)[R_1 + R_2 - z \tan|\theta|] & \text{for } |\theta| > \theta_g, \end{cases}$$

where

$$\theta_0 = \tan^{-1} \frac{R_2 + R_1}{z},$$

$$\theta_g = \tan^{-1} \frac{R_2 - R_1}{z}.$$

The equation of $A_{12}(\theta)$ for $R_2 \leq R_1$ is identical to that above, except that R_1 and R_2 are interchanged.

This expression for $A_{12}(\theta)$ is valid for one-dimensional apertures only. In two dimensions the shapes of both apertures must be specified. For example, if both apertures are circles, we must consider the intersection of an ellipse (the projection of the first aperture) with a (relatively) displaced circle. However, the development is straight-forward.

In this one-dimensional aperture configuration it is clear from $A_{12}(\theta)$ that all light which passes the first aperture at $|\theta| \leq \theta_g$ is unaffected by the second aperture. That is, this factor of the optical transfer function is a constant for the spatial "frequency" band $|\theta| \leq \theta_g$. If $R_1 < R_2$ then θ_g can be maximized by minimizing z (z can never be zero if a physical lens is located in the plane of the second aperture).

Considering only these geometrical restrictions, the optimum placement of a pattern and aperture is as close as possible to the lens in the plane of the second aperture. Also, the second aperture (at most the size of the lens) should be as large as possible. However, the complete optical transfer function may specify a different optimum location.

References

[1] Born, M. and E. Wolf, Principles of Optics, Pergamon Press, New York, 1959.

[2] O'Neill, E. L., Introduction to Statistical Optics, Addison-Wesley Publishing Company, 1963.

[3] Kozma, A. and D. L. Kelly, "Spatial Filtering for Detection of Signals Submerged in Noise," Applied Optics, Vol. 4, No. 4, pp. 387-392, April, 1965.

[4] Marechal, A., "Optical Filtering by Double Diffraction," Optical Processing of Information (Eds. Pollack, D. K., et al, Spartan Books, pp. 20-30, Baltimore, 1963).

[5] Armitage, J. D. and A. W. Lohman, "Character Recognition by Incoherent Spatial Filtering," Applied Optics, Vol. 4, No. 4, pp. 461-467, April, 1965.

3. SOFTWARE SYSTEMS RESEARCH PROGRAMS

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3.1 ILLIAC II Program Development

3.1.1 Progress

Planning for the future time-share system has taken place. Work in the next quarter will concentrate on the development and implementation of this new system.

For the purpose of aiding in the interconnections, documentation and planning of the future time-sharing system, a flow chart printer for the 1401 was written. By supplying the program with a minimal amount of information through the use of data cards, a flow chart complete with arrows, different shaped boxes, and comments is produced.

Programming is being done for the PDP-7 in the areas of testing, simulating, code conversions and subroutine library. Interfaces with the PDP-7 are specified. In the meantime, a small time-share language called LTLTRAN is being planned for use on the PDP-7.

A program called BØØTS, a modified version of the old file update, has been written.

3.1.2 Flow Chart Printer

A program to read in cards which describe a flow chart and then print the chart using the 1403 printer has been coded. Certain basic features of it are running now, some are being coded and code checked, and still others are yet to be implemented. The input cards are easily punched directly from a flow chart drawn on the department standard flow-charting form. This form permits six kinds of boxes in a five by ten matrix of boxes. There are altogether fifteen statements that will be recognized by the program for the purpose of describing and altering flow charts. The type of box, comments it contains, placement of the box on the paper, direction of connecting arrows, titling and dating of the chart,

number of copies to be printed, etc., are all handled by these control statements. The flow chart produced is easy to read on two sheets of output paper. When completed, this program will store these charts on tape so that copies may be printed at any time and changes may be made without changing cards in the original deck. Some work is being done on modifying this program so that diagrams will come out on the CalComp. It is believed that this CalComp version will only be used for publication drafts because of the relatively slow speed of the plotter.

A complete description of this program was distributed on August 4, 1965 as a memorandum.

3.1.3 Present Time-Sharing System

A time-share system was put into operation September 15, 1965, which allows batch processing, one teletype, and one IBM 1050 Console to be run simultaneously. FØRTRAN and NICAP are available from the teletype and SØC (the Simple Online Calculator program) is available from the 1050. This system is in use a good part of the day and is in the final stages of debugging and polishing. A more elaborate operator communications set-up is now in use and machine errors are now noted on the console typewriter.

BØØTS, a bootstrap time-shared program may be used with the time-share system. It drives the teletype. BØØTS allows programs to be input through batch processing or via the teletype and saved on tapes for subsequent running and debugging. Some of the schemes that are being planned for the future time-share system have been studied and are being implemented in BØØTS for the purpose of studying and testing them "under fire." A more important reason for implementing BØØTS was for the debugging with the help of a simulator, of the future time-share system itself.

A memorandum titled, "Use of Time Share," was distributed on September 8, 1965.

3.1.4 Future Time-Sharing System

The future time-share system has now been split up into five major packages: on-job monitor, scheduler, file-by-name, overlap, and command processor. The interfaces between the packages are now being specified. File-by-name and the associated sort-merge package are now being programmed and will be implemented

in the present time-share system at a later date. The related garbage collection routines are fairly well specified but programming on these will not begin until much later. The command language description is completed and the commands have been split into three groups--those that will be implemented initially, those that will be implemented as soon as possible after the system goes into operation, and those super-commands which would be nice to have but which are not essential. Overlap has been flow-charted and shelved until a later date. Planning of the on-job monitor and the scheduler is continuing.

A simulator to simulate the ILLIAC II tape, disk, drum, and PDP channels, and to allow the future time-share system to be debugged from the teletype console during regular code checks has been laid out in detail and programming has begun.

Documentation in the form of programming memorandums was continued throughout the summer and has proved invaluable for bringing new members of the time-share group up to date. The memorandums will continue to be used since coordination and communication will become even more important as the project progresses. The pertinent ones for this quarter are:

Title	Source	Date
Thoughts on a Command Language	Prog. Memo. #16	July 7, 1965
User File Commands	Prog. Memo. #17	July 26, 1965
File-By-Name	Prog. Memo #18	July 23, 1965
Overlap and Interrupt Controlled I/Ø	Prog. Memo. #19	July 30, 1965
Relations Among ILLIAC II, PDP-7 Software Interface, Time-Share Core Layout, Command Language Processor	Prog. Memo. #21	August 5, 1965
A Proposal for Saving Core Loads	Prog. Memo. #22	August 10, 1965
Organizational Details of File-By-Name	Prog. Memo. #27	September 28, 1965

3.2 Programs for Peripheral Hardware for ILLIAC II

3.2.1 PDP-7 Programming

Test and operating programs for the PDP-7 have been written, assembled, and debugged using the PDP-7 simulator on ILLIAC II. The PDP-7 itself is to arrive sometime in the next quarter.

Coordination with DEC (Digital Equipment Corporation, manufacturer of the PDP-7) has resulted in a set of machine orders and mnemonics for control of the 630 Data Communication System, and the SPU--ILLIAC channel. These orders have been incorporated into the University of Illinois version of the PDP-7 assembler.

A good part of the test programming effort was in determining how to use available test programs and in finding requirements for new ones. IBM literature was probed to find the proper sequence of control for the IBM 1050 console. A report from this effort was published and a test program for the IBM 1050-PDP-7 interface has been written. Similar programs to test the teletype consoles and 633 flag scanner have been planned.

Paper tape to cards, and cards to paper tape programs have been written for all combinations of PDP-7 and simulator formats. These will allow for the full flexibility of using the simulator to assemble PDP-7 programs from cards but to run them from tape.

Standards of programming and documentation for the PDP-7 were developed from discussion with DEC personnel and from study of their programs and write-ups. These standards are documented in a programming memorandum. A library of standard PDP-7 subroutines, particularly in the area of console communication has been started. These routines can be combined with control routines and thus made into test or service programs for the PDP-7.

An interface specification between the PDP-7 console system and the ILLIAC II time-share system has been produced. This specification is allowing both programming efforts to develop independently.

3.2.2 LTLTRAN

Design of LTLTRAN, a small time-share language, was started for use on the PDP-7. This language offers highly interactive, algebraic use of five remote consoles on the computer. Later, this language will be expanded to be available to all consoles from the ILLIAC II time-share system. The five console versions on the PDP-7 will provide service during periods when ILLIAC II is not available.

LTLTRAN is in appearance a small subset of FØRTRAN II with additional commands for console control. LTLTRAN has been completely specified in a programming memorandum.

In planning the interrupt programs for the PDP-7, a new charting method was formalized. This charting method supplements program flow-charting by clearly showing control action and overlapping in time-share programs. The charting method is documented in a programming memorandum.

Publications from this area for the quarter include:

Title	Source	Date
The PDP-7 Simulator on ILLIAC II	Memorandum	July 14, 1965
Trip Report, Digital Equipment Corporation	IØHG-22	July 27, 1965
The PDP-7 Simulator on ILLIAC II, Addendum	Memorandum	July 28, 1965
PDP-7 Programming Schedule	Prog. Memo. #20	July 30, 1965
LTLTRAN on PDP-7, Preliminary Specification	Prog. Memo. #23	August 16, 1965
Programming Standards for the PDP-7	Prog. Memo. #24	August 17, 1965
PDP-7 Programming for the 630 DCS	Prog. Memo. #25	September 10, 1965
PDP-7 To ILLIAC Channel Programming	Prog. Memo. #26	September 17, 1965
PDP-7 Order Code	Prog. Memo. #28	September 29, 1965
A Presentation Method for Interrupt Programming	Prog. Memo. #29	September 29, 1965

3.3 CLIC

This section describes the basic procedures used to implement the CLIC[1] language. CLIC is a compiler in which the modification of a single statement requires the modification of only the code produced by the statement in question and does not require a complete recompilation of the program. The justification for and external characteristics of such a language are presented elsewhere.[2]

The compiler discussed is described in somewhat abstract terms with only the salient features being presented. The resultant language is the same as CLIC in operation, but not strictly complete in syntax. (CLIC is FØRTRAN-like in syntax.)

To begin our discussion, four types of statements are desirable in our compiler language. The first is the operation, substitution, or assignment statement. In general this statement contains an equal sign (as in FØRTRAN, ALGOL, MAD, etc.) or an equivalent verb.

The second type is the control statement. This changes the logical flow of the program from the normal or natural order. This type of statement makes reference to the location of other statements (FØRTRAN "IF" or "GO TO," etc.).

The third general class are the input/output statements. This class includes any reference to peripheral devices.

Finally, we have the declarative statements. Such items as storage assignment and variable mode declarations are handled here (FØRTRAN "DIMENSION" is an example.)

For our purposes we shall define a simple language which will embody all of these components. In general the language will consist of statements which have the gross syntax:

<LABEL><STATEMENT BODY>

Each statement will be distinct from any other statement.

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1 CLIC--Console Language Immediately Compilable, a project at the Department of Computer Science, Quarterly Technical Progress Report, October-December, 1964, University of Illinois, Urbana, Illinois.

2 The reader is referred to Department of Computer Science File No. 666, "The Concept of an Editable Compiler Language," by Edwin B. Hassler, June 21, 1965.

The LABEL will consist of two parts. The first part defines the NATURAL ORDER of statements. NATURAL ORDER is defined as the order in which the statements would be executed if nor control statements modified this order. Each statement will have a unique NATURAL ORDER indicator. The second part of the LABEL is the user-defined reference portion; that is, the identifiers which the user assigns to statements so that he can reference them in control statements. This need not be distinct from the NATURAL ORDER, but the two parts are presented separately for clarity.

The STATEMENT BODY can be as complex as necessary or desirable. The one restriction is that it cannot have any of the properties of a LABEL.

In particular, the statement types shall have the following properties.

Substitution and I/O statement have the same properties. They can:

1) implicitly or explicitly define variable storage;
2) implicitly or explicitly call for the use of a subroutine;
3) bear a LABEL.

Control statements can:

1) reference labels;
2) implicitly call for the use of a subroutine;
3) bear a LABEL.

Declarative statements can:

1) declare mode;
2) allocate storage.

Declarative statements cannot bear a LABEL.

It must be noted at this point that the deletion of any statement from a program can undo any definition which has been made. To keep the information necessary for compilation and modification, the following tables will be maintained:

1) Variable storage allocation. This table contains:

    a) the BCD name;
    b) the address of the symbol in the data area;

c) a count of the usage of the symbol;

d) a specification of the storage arrangement (simple variable, array, etc.).

2) LABEL location table. This table contains:

a) the indication of NATURAL ORDER;

b) the storage location of the resultant statement code;

c) the user's LABEL (if any);

d) an indication of references to this LABEL.

3) The subroutine table. This table contains:

a) the subroutine names;

b) the subroutine locations.

4) Scratch and linking table. This table contains notations of unlinked transfers (i.e., cases where reference is made to an undefined LABEL).

One other major table might be considered for a practical system. This is a table of pointers to the user's source language statements. These will be needed to keep the source language up-to-date with the modifications, or if it is necessary, to totally recompile.

Two phases of this compiler can be considered. The first is compiling and building the original program. This will be ignored, as it is a commonplace operation, and the rest of this paper devoted to the problem of modifying an existing program. However, it must be noted that this compiler will produce the required tables and provide the resultant machine code in relocatable labeled blocks, one block per statement.

The problem of program modification can be broken into two areas--the addition of a statement and the deletion of a statement. The modification of a statement is the same as the case of a deletion immediately followed by an addition, both statements involved having the same NATURAL ORDER.

The problem of addition of a statement of the substitution or control types to a program in memory is easy to solve provided extraneous orders (in the ordinary program sense) in the form of transfers are used to link the statements

in NATURAL ORDER or in the order directed by control statements. Then the addition problem is one of adding to tables and rerouting links to insert this statement.

Consider the following example:

NATURAL ORDER	USER LABEL	STATEMENT BODY
10	10	x = a
20	20	GO TO 10
30		END

which in memory is linked as shown in Figure 1.

Now consider modifying the program with a substitution to read:

NATURAL ORDER	USER LABEL	STATEMENT BODY
10	10	x = a
20	20	GO TO 10
30		END
15	30	y = b

(the revision in NATURAL ORDER is user-specified) which in memory is now as shown in Figure 2.

To accomplish this, the variable storage allocation table would have to have y and b inserted, and the LABEL location table would need an entry corresponding to label NATURAL ORDER 15, user LABEL 30. (Incidental to this, the code for "y = b" will also be compiled.)

The fact that a and b are undefined in the above program segment is of no consequence to the modification of the program structure. This is a modified case of caveat emptor. Let the user beware!

Now we must consider the addition of a control statement which references a LABEL. Suppose we had wished the modified program to read:

NATURAL ORDER

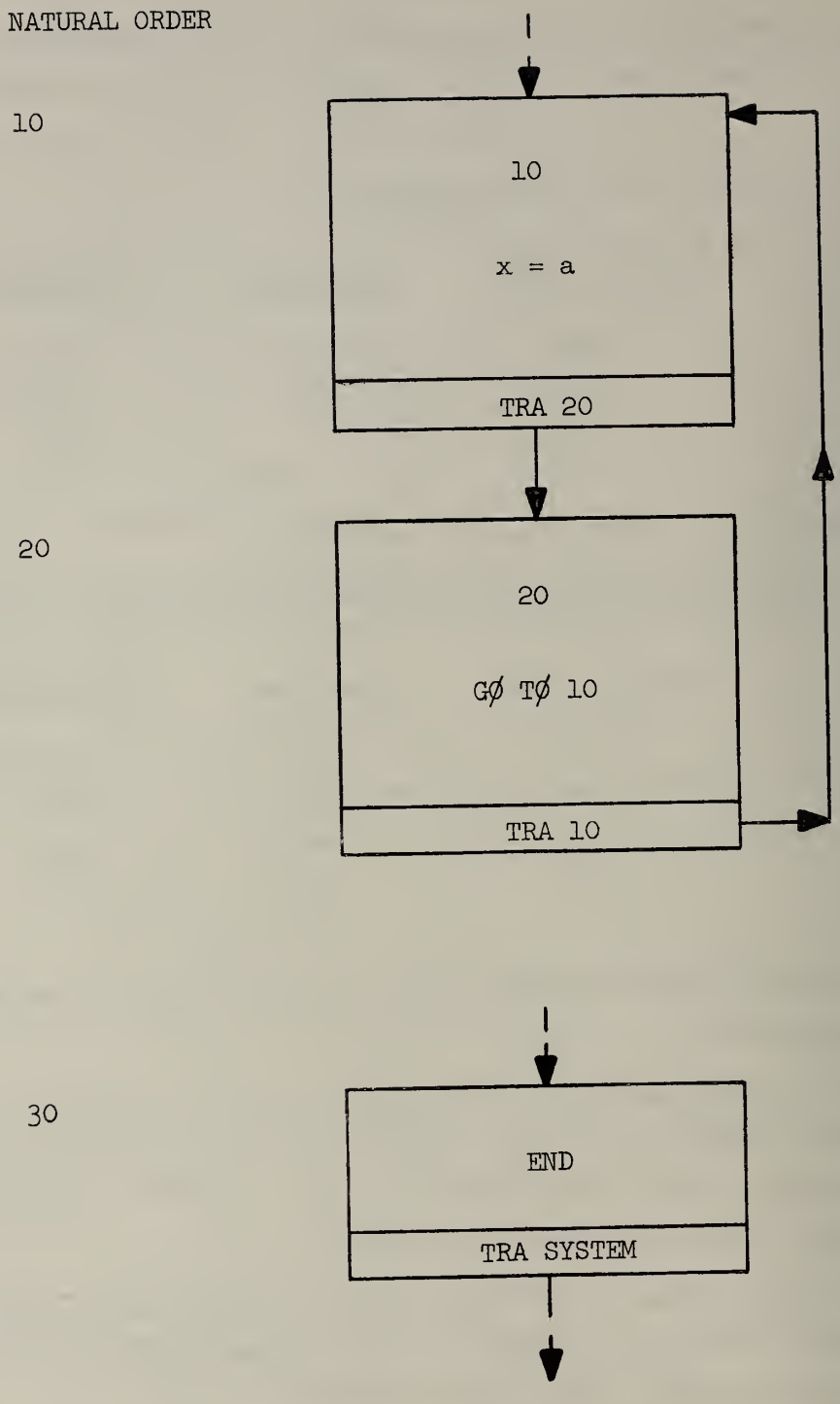

FIGURE 1

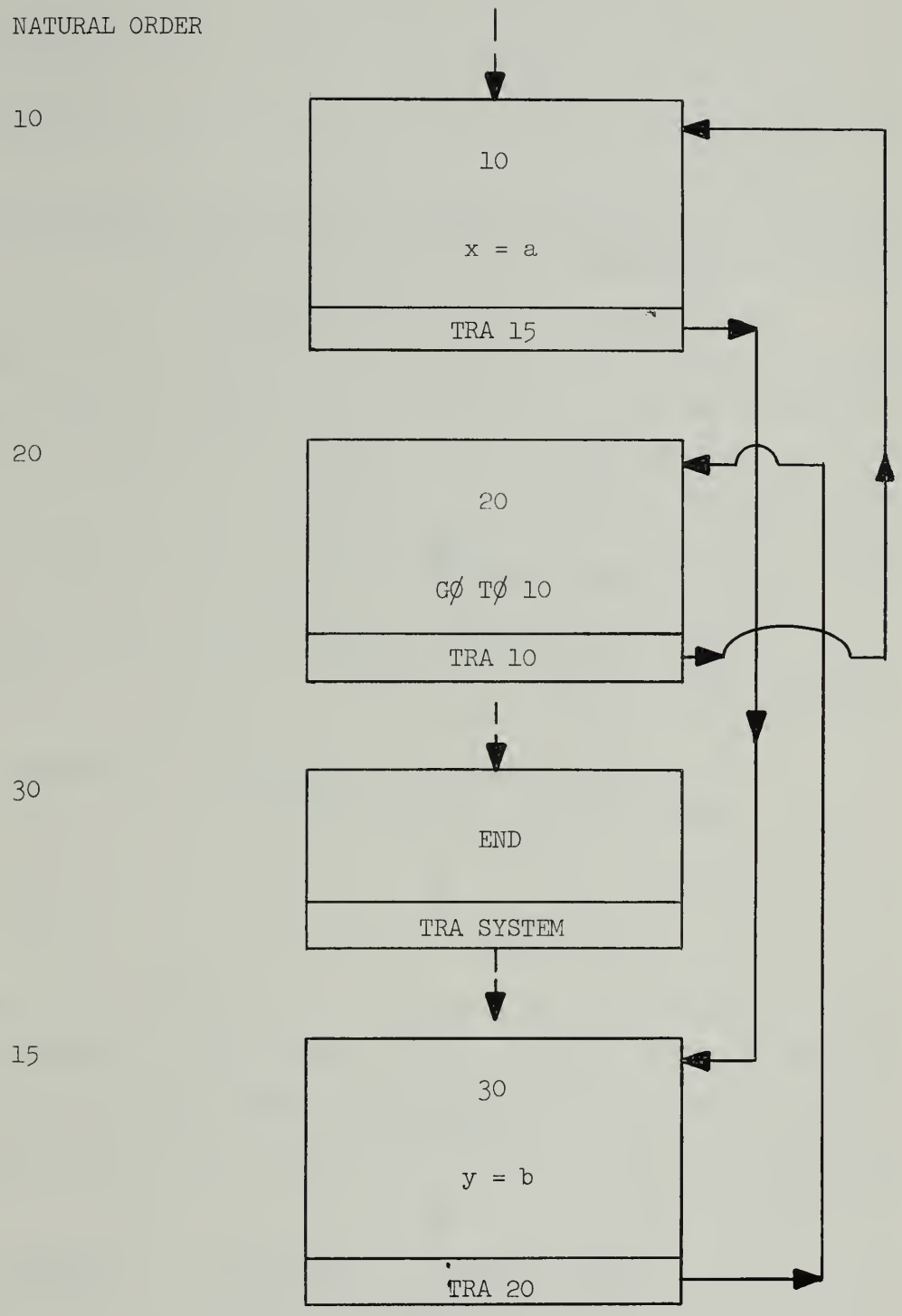
NATURAL ORDER
10
20
30
15
10
x = a
TRA 15
20
GØ TØ 10
TRA 10
END
TRA SYSTEM
30
y = b
TRA 20

FIGURE 2

NATURAL ORDER	USER LABEL	STATEMENT BODY
10	10	x = a
20	20	GO TO 10
30		END
15	30	GO TO 99

In this case an entry must be made in the scratch and linking table indicating reference to user LABEL 99, which does not yet exist.

The other major case to be considered is the deletion of a statement. Again, the action must be dependent upon the existence of a LABEL. Consider first eliminating the control statement of NATURAL ORDER 15 from the example above. Two things must be watched. First, does the user LABEL 99 appear in the scratch and linking table? Second, is user LABEL 30 ever referenced? If user LABEL 99 appears in the scratch and linking table, it must be removed. If user LABEL 30 is referenced, a notation must be made of this in the scratch and linking table.

Let us consider another example, eliminating the assignment statement of NATURAL ORDER 10 from:

NATURAL ORDER	USER LABEL	STATEMENT BODY
10	10	x = a
20	20	GO TO 10
30		END

In this case an entry must be made to the scratch and linking table about the reference to the portion of code which used to be user LABEL 10. In memory the structure would be as shown in Figure 3. Note that the transfer "A" indicated in Figure 3 still exists, and that the existence of the block of NATURAL ORDER is retained in the scratch and linking table. The resultant program above is:

NATURAL ORDER	USER LABEL	STATEMENT BODY
20	20	GO TO 10
30		END

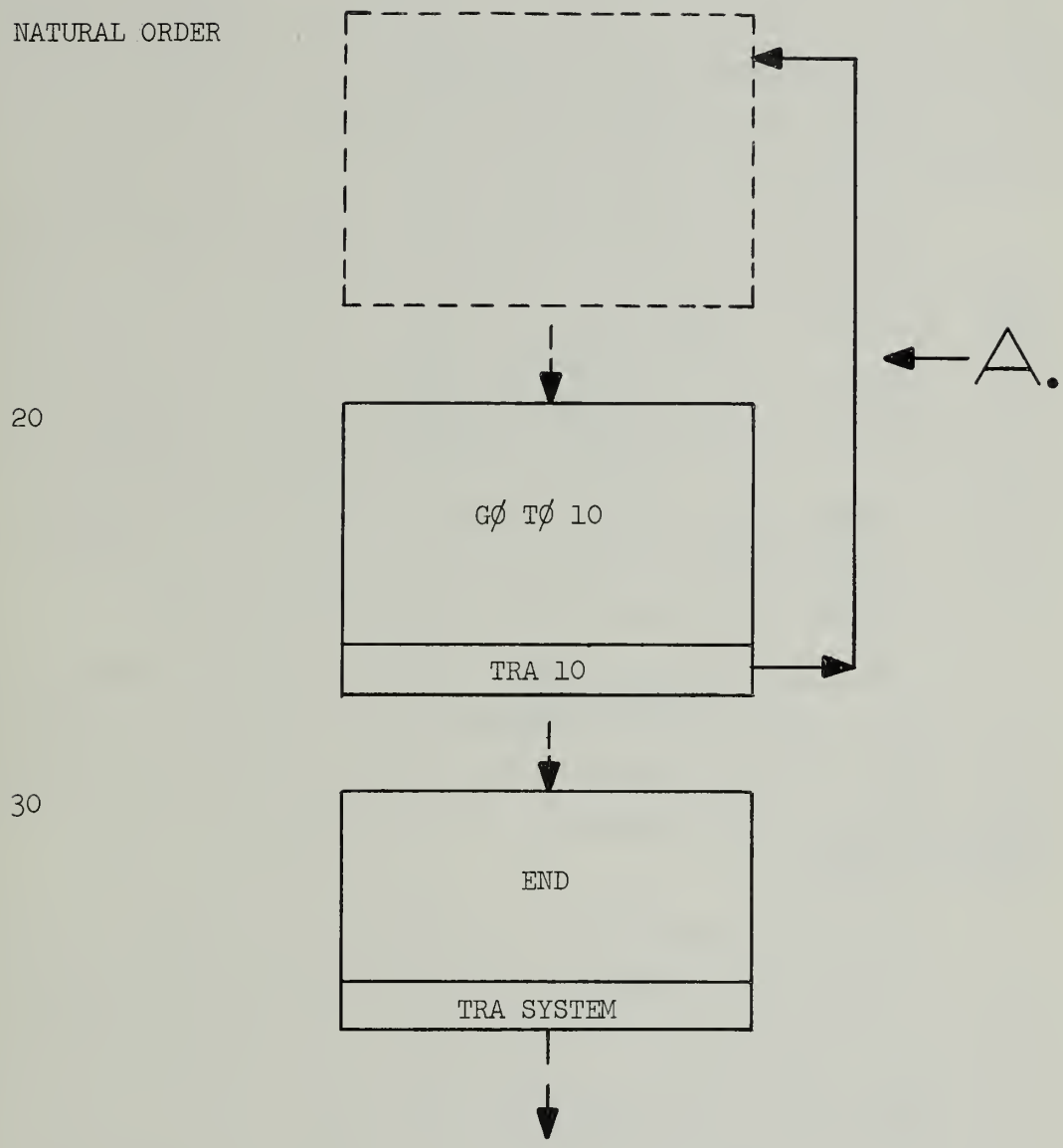

FIGURE 3

Now if the program were expanded to read:

NATURAL ORDER	USER LABEL	STATEMENT BODY
20	20	GO TO 10
30		END
25	10	y = b + c

the new code could be inserted in the place of the residue of the old statement 10, x = a, provided the space were sufficiently large. However, if the space is not large enough, the structure will be as shown in Figure 4.

The effect of this procedure is a single location in core used as a linking transfer (the "TRA 25") followed by an empty area. (It might be desirable to make note of this empty area to attempt to utilize it at a later time.) Another effect is that this TRA 25 has been eliminated from the scratch and linking table and an entry of user LABEL 10, NATURAL ORDER 25 has been placed in the LABEL table. As far as the program is now concerned, the TRA 10 in the statement of NATURAL ORDER 20 is really (and effectively) a TRA 25. Except for the unavailability for use of the cell which contains the TRA 25, all mention of the statement which was originally NATURAL ORDER 10 has been eliminated.

In summary of this point, each substitution or control statement knows where control goes when it is finished, but not where this control came from. That is, substitution statements simply transfer control to the next statement in NATURAL ORDER at their conclusion. Control statements transfer control to their respective objects.

From these examples, it is seen that the scratch and linking table really is composed of two parts. The first part is a table of memory locations to which references are made but from which the pertinent LABEL and accompanying statement has been deleted. The second portion is a table of references which have been made before the LABEL has been defined. In this second portion of the table, it would be desirable to keep the location of each reference as a separate entry in case the reference is erroneous and will be deleted. In general, it should be noted that all references to a LABEL should be counted so that unnecessary entries are not made in the scratch and linking table when a LABEL-bearing statement is deleted.

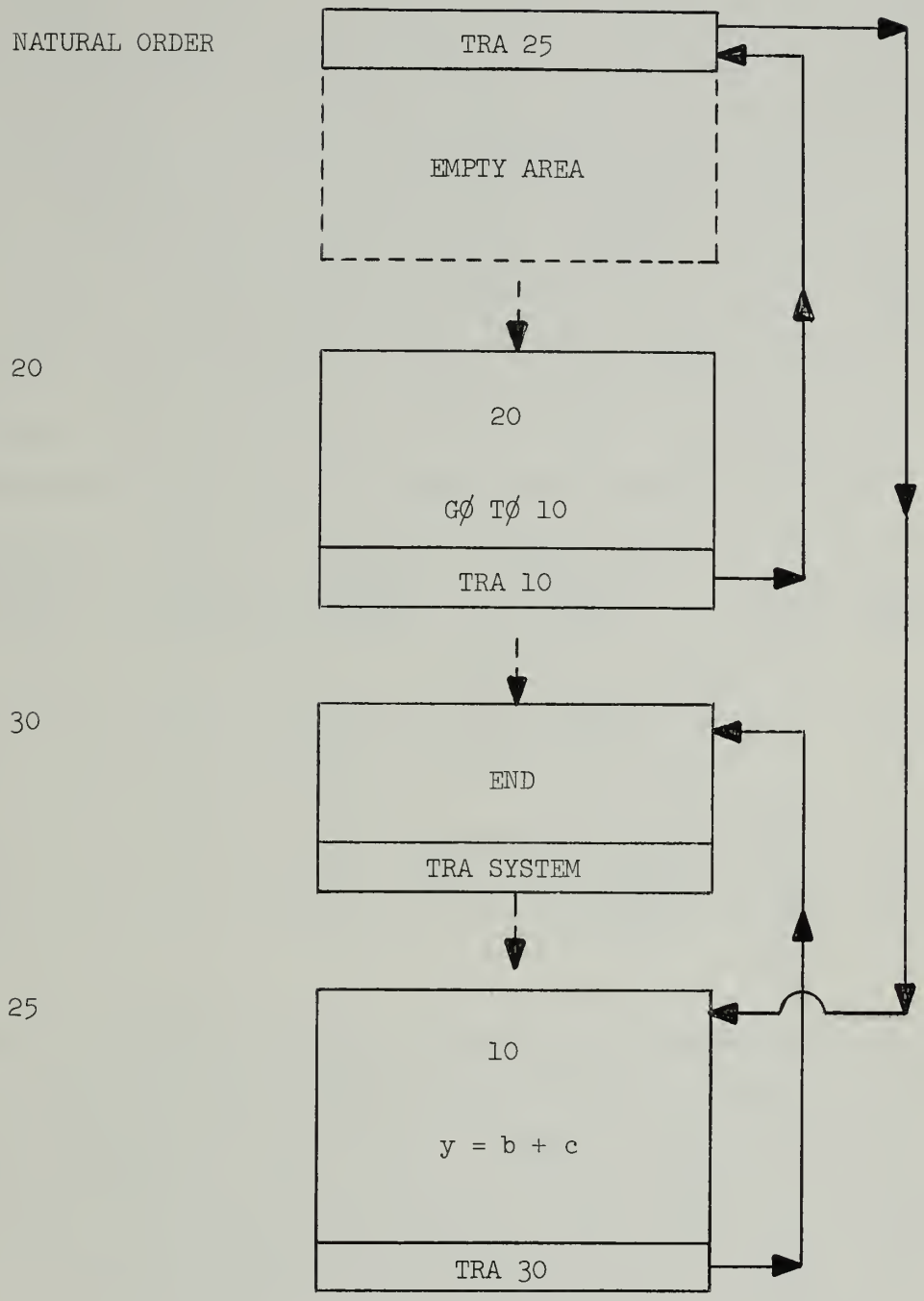
NATURAL ORDER
TRA 25
EMPTY AREA
20
20
GØ TØ 10
TRA 10
30
END
TRA SYSTEM
25
10
y = b + c
TRA 30

FIGURE 4

So far only the simple control statement has been considered. The remaining type of control statement to be considered is the iterative control statement (in FØRTRAN the "DØ" statement). The first problem is one of the legality of transfers to and from the range of control of an iterative statement. With little effort it can be seen that all that is needed are two monotonic sequences--one sequence increasing with increasing NATURAL ORDER and changing to the next sequence member at each iterative statement range boundary. This sequence is used to control transfers in the direction of increasing NATURAL ORDER. The other series decreases as NATURAL ORDER decreases, changing to the next sequence member at each iterative statement range boundary. This sequence is used to control transfers contrary to NATURAL ORDER. In either case, the NATURAL ORDER at the limits of each iterative statement range will be sufficient to define the members of this sequence. For an example consider:

NATURAL ORDER	USER LABEL	STATEMENT BODY	FORWARD SEQUENCE	APPLIED DEFINITION	REVERSE SEQUENCE	APPLIED DEFINITION
10		DO 20 i = 1, 10	0	0	> 60	
20		x(i) = y(i2)	10	10	60	
30		DO 10 j = 1, 10	10		60	
40		z(j) = a(j)	30	30	50	
50	10	CONTINUE	30		60	50
60	20	CONTINUE	10		60	60
70		END	0		> 60	> 60

where the areas before and after the range of an iterative statement have been assigned a number such that the sequence is monotonic in the proper sense. Also note that the sequence appears to be monotonic as opposed to strictly monotonic unless it is remembered that the forward sequence members are only those NATURAL ORDER numbers at the start of the range of each iterative step, and the reverse sequence those at the end of the range for each iterative step. The restrictions on the transfers are:

for forward transfers: object forward sequence $\leq$ source forward sequence;

for reverse transfers: object reverse sequence $\geq$ source reverse sequence.

With this technique, the deletion of an iterative statement involves modifying only the sequence as it applied to the range of the now-removed iterative statement. To add an iterative statement involves some complexity of transfer investigation. Provided the statement can be properly nested in existing ranges which is verified using the forward sequence, all transfers within the next outermost range must be checked for validity under the new situation. If the earlier suggestion of indicating all LABELS which are referenced is followed, some effort can be saved in the event that there are no transfers into the range of this iterative statement. Note that for ease of checking,each statement should either carry its sequence number with it or the sequence numbers should form another table.

Some comment must be made about declarative statements. They will control three characteristics--storage allocation, variable type and program type. Those which concern variables depend for their treatment on the method of handling the variable. In this case, a table-driven scheme has been used. Assuming this is a code-producing compiler (as opposed to an interpretive language) the necessary restriction must be that the declarative statements must appear chronologically before the first occurrence of the variable.

In the case of the storage allocation statement (such as FØRTRAN "DIMENSION") this can be relaxed to the extent that the storage allocation can be reordered as long as the total storage area required does not increase in size.

All other types of change involving a declarative statement will require a complete recompilation of the program. Recompilation could be eliminated if each reference to a variable were through a storage allocation routine (i.e., execution time storage allocation). This, however, produces compilations if the user ever wishes to remove the extra storage required by the modification linking mechanism and obtain a compact program. Also, it is very nearly like an interpretive routine and is similarly undesirable as a result of the extra execution time required.

To summarize, a language with the gross syntax:

<LABEL><STATEMENT BODY>

which includes:

1) arithmetic statements;

2) control statements, including iterative statements;

3) input/output statements;

4) fixed-mode variables and fixed-storage allocation;

and which allows the use of subroutines has been described. The language is an editable compiler language in the strict sense. If declarative statements concerning storage allocation are included, the result is a slightly modified editable compiler language in the sense that some modifications to storage allocation statements can cause recompilation rather than editing. If declarative statements concerned with variable mode are allowed, the language becomes uneditable compiler language with respect to those particular statements.

At the present time CLIC which is based on the preceding premises is basically operational. When the general purpose time-sharing system now under development for ILLIAC II is operational, CLIC will be modified to fit into this system.

3.4 Hardware for ILLIAC II

3.4.1 Multiplexing Special Register System

The Multiplexing Special Register System is now considered to be a totally operating component of ILLIAC II, with two functional Subsidiary Registers attached to Teletype equipment and two more (Teletype) Subsidiary Registers nearing completion. The necessary interface circuitry has been designed, built, and checked out to interconnect the Teletype Subsidiary Registers to Teletype sets, Bell 103A Data Sets, or to Low-Speed (Crockett) Data Sets; additional circuitry has been developed to connect Teletype units to Bell 103A Data Sets.

A novel shared-interrupt scheme has been implemented in the Multiplexing Special Register System. It will be recalled that the system, as constructed, is capable of handling up to 64 Subsidiary Registers, each of which may be thought of as a slow, character-by-character data port. Each such data port is attached to a device comparable to a Teletype unit; for timing estimates, all ports will be assumed to be 100 words per minute, eight level Teletypes. The real-time systems problem is, then, easy to define: assuming that all data ports are concurrently sending characters to ILLIAC II at the maximum possible rate, guarantee that no characters are lost. Now 64 data ports operating at 100 words per minute will produce 64 characters in every 100 ms interval; however, the problem is somewhat worsened by the conventional money-saving technique of single-buffering data ports. The N-th chronological character in the buffer of a data port, in transit from a device to ILLIAC II, is only valid for about 15 ms, after which it commences to be overwritten by the incoming (N+1)-th character.

The traditional noninterrupt method of handling the real-time problem above is to sample the state of each data port as a sufficiently high rate to preclude missing characters: the 15 ms validity length necessitates a sampling rate in excess of the 60 c/s maximum interrupt rate of the existing clock on ILLIAC II. Additionally, the efficiency of this method is quite low under conditions of low data port usage; each data port must be sampled regardless of what the samples yield.

The traditional interrupt method of handling the real-time problem is to allow each data port to interrupt the central processor whenever its buffer contains a valid character. This method is, indeed, efficient at low data port usage rates, but at high usage rates the efficiency is quite bad since there will always be one interrupt per character received. If one assumes that 150 μs is required to process each interrupt, then maximum data port usage will force ILLIAC II to spend ten per cent of its time handling interrupts caused by Subsidiary Registers.

The scheme which has been implemented is as follows: when one of the data port buffers has become valid, a timed delay is initiated; when this timed delay, of length somewhat shorter than the validity length, is completed, the main processor is interrupted. The processor then samples all data ports and resets the delay counter circuitry. It is noted that, at low data-rates, this scheme is equivalent to the traditional interrupt method; at high data-rates, it is equivalent to the traditional noninterrupt method.

By a fairly obvious extension, it may be seen that the output case is governed by the same remarks as were made for the input case; however, data is not lost on output by mere slowness on the part of the central processor. As implemented in the Multiplexing Special Register System, output is handled by the same shared-interrupt as is input.

3.4.2 Device Interface Register

A report has been written documenting the Device Interface Register, mentioned in a previous Quarterly Progress Report. This report details all the options available and the differences between this register and its predecessor, $SR76_8$.

"Special Register $SR52_8$," by F. A. Rohatsch, Department of Computer Science, File No. 671, July 1, 1965.

3.4.3 Disk File Interplay Channel

The first Disk File Interplay Channel has now become an operational part of ILLIAC II. A comprehensive read-around test was programmed, involving both worst-case data and random data; this test was used on several extended runs to examine all data areas on 1301-A. No bad spots have appeared to date.

A detailed set of diagnostic tests has been organized, partially programmed, and essentially debugged. The individual tests have been written in modular form and are cycled by a control routine which is able to lock them in and out, transfer print and action control to them, and perform other useful monitor functions to aid in localizing suspected faults.

The basic document describing disk file operations has received a major update, to reflect changes to the Channel incurred during debugging:

> "Programming Aspects of the Disk File Channels," by R. E. Willard and S. J. Nuspl, Department of Computer Science, File No. 620, Revised, August 2, 1965.

3.4.4 Satellite Processor Communications System

It was decided that the processor of the Satellite Processor Communications System would be a PDP-7, built by the Digital Equipment Corporation. In view of the capabilities of the PDP-7 and the type of communications to be conducted between it and ILLIAC II, it was decided to connect the two machines via two nonstandard Interplay Channels. Whereas standard Interplay Channels are half-duplex channels, the two Satellite Channels are simplex channels (one channel for input and one for output), with the further constraint that concurrent data transfers are not possible. The structure of two simplex channels instead of one half-duplex channel gives greater flexibility to the ILLIAC II programmer; the constraint of nonconcurrency of data transfer allows the two logically separate Interplay Channels to share a common word buffer.

It is anticipated that the data transfer rate will approach eight μs per (ILLIAC) word. Data transfer is totally overlapped by both the central processor and the satellite processor; data transfers steal core cycles as needed in both machines. The Special Registers associated with these Interplay Channels follow the conventions established in Department of Computer Science File No. 517.

The logical design of this channel-pair has been completed and rack wiring is underway. The necessary construction of printed circuit boards has been initiated, and the required new boards and new circuits are under development.

Section 3 of the Quarterly Progress Report has been written by J. Aaron, J. Ahlstrom, S. Chase, R. Fisher, C. W. Gear, L. Greninger, M. Haas, E. Hassler, W. Heimerdinger, J. Kelly, A. Leal, S. Nuspl, M. Pisterzi, F. Richardson, C. Shepard, R. Willard and Y. Yen.

4. THE ILLINOIS PATTERN RECOGNITION COMPUTER: ILLIAC III

(This work is supported in part jointly by the Atomic Energy Commission and the Advanced Research Projects Agency under Contract AT(11-1)-1018 of the Atomic Energy Commission.)

4.1 System Programming

A formal ILLIAC III Programming System Group has been organized. This group is headed by Professor Manfred Paul. Three areas of immediate responsibility are discussed below:

4.1.1 IBAL-Compiler

As a convenient means to write programs for the ILLIAC III Computer the recalled ILLIAC Basic Assembly Language (IBAL) has been designed. In this interim stage of development it is necessary to provide compilers for IBAL which translate the latter language into the machine codes of both the ILLIAC II and the ILLIAC III. The machine code produced by such a compiler has to be efficient with respect to both time and storage space since IBAL will be the language in which most of the system programming is done. Two men of the group, J. Schwebel and A. Gonzales, have begun with the first of these compilers which will run on the ILLIAC II and translate IBAL into ILLIAC II-code. So far the following has been accomplished:

1) It has been decided that we shall employ for IBAL translation essentially the same techniques that have made ALCOR ILLINOIS 7090/94 very efficient in both translation-time and execution time as well.

2) The general outline of the IBAL-compiler has been discussed thoroughly. According to these discussions there will be four passes.

3) Flow charts for pass 1 have been drafted and will be set up in more and more detail as work goes on.

4) Actual programming of pass 1 is just beginning.

4.1.2 Multiprogramming

Another essential task of this group will be to provide the package of service routines necessary to create a time-sharing system.

1) Here, there is the CONTROL routine, which schedules the time and storage space for each program to be executed. It also keeps lists in which information about the users and their programs is stored, e.g., priority list, waiting list, etc.

2) The time sharing system contains also a communication program which allows users from multiple remote consoles to ask questions about the current status of the computer itself. This communication routine will then answer such questions. It should also allow the user to make minor changes and/or corrections in a program which just is being read in. Furthermore, it should be possible to let the communication routine make certain portions of a program ready for execution.

   These features would considerably facilitate testing and debugging of programs written by users.

3) Finally, the service system includes the I/Ø package, the loaders for all available kinds of backup storage, and the routines which manage the information flow between the visual displays and the computer.

So far the group has discussed Section 1) rather thoroughly. Flow charts for this portion are being drafted. Discussions on the design of Section 2) are under way.

The scheme for the CONTROL routine as it is planned at the present time is as follows: Every program which is offered to the computer for execution gets a certain priority depending upon both the programmer and the nature of his program. Programs of the same priority class will be executed in the order in which they were input.

4.1.3 Compiler-Compiler

This third job of the Programming System Group comes under a well-known name. It is also very well known what a compiler-compiler is supposed to do. It is, however, unfortunately enough less well known how to build a decent generator of compilers for a fairly general class of languages, e.g., CHOMSKY-2-type languages (context free languages).

All that is known from the theory of formal languages is an algorithm which transforms the given sets of productions of certain CHOMSKY-2 languages into the production sets of equivalent CHOMSKY languages such that these new productions allow a straightforward scanning without leading to dead ends. This algorithm therefore generates what one might call the syntactical part of the compiler for a given CHOMSKY-2 language.

The semantical part would be an algorithm that produces a piece of code according to the parse which was delivered by the syntactical analyzer. To create this semantics handling part is difficult as not much theoretical work has been done so far.

Therefore, the group is starting its work with the syntax part of the compiler-compiler. Flow charts for the first step are drafted. In this first step the given set of productions is transformed into a simpler one in which all critical productions are of length one.

4.2 Scheduling

A memorandum has been prepared that lists by area of the ILLIAC III Project all presently known tasks that must be completed prior to actual checkout of the machine logic.

The areas used are as follows:

	Area	Tasks
1)	Main Frame	11
2)	I/O System	19
3)	Scanner/Monitor Center	43
4)	Power/Control System	44
5)	Video Communications Net	14
6)	Test Equipment and Testing	25
7)	Printed Circuit Cards	29
8)	Documentation	21
9)	Logical Design	36
10)	System Programming	Unspecified, see above
	Total Tasks	242

A systematic estimate of the information yet required, manpower requirements, key personnel and precedence requirements of each task is under preparation. This newly created and revised data will be used to provide PERT-type project control.

B. H. McCormick, Principal Investigator
S. R. Ray
M. Paul
J. L. Divilbiss

5. NUMERICAL METHODS, COMPUTER ARITHMETIC AND ARTIFICIAL LANGUAGES

(Supported in part by the National Science Foundation under Grant No. NSF-GP-4636.)

5.1 General Comments

No people were employed under this contract during the summer, so this report covers the two-week period, September 15 to September 30, 1965.

A start was made on an optimization program to search for extrapolation factors, different for each equation, for the solution of systems of equations by successive over-relaxation.

Work on which the following paper* is based was performed prior to the awarding of NSF Grant No. GP 4636. The contents of the paper represent a step toward the research goals of the grant, and hence are reported here. The paper will appear in "Proceedings of IFIP Congress 65," Vol. 2, Spartan Books, Inc., Washington, D. C., and Macmillan and Co., Ltd., London.

D. B. Gillies, Principal Investigator
J. E. Robertson

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* Robertson, J. E., "Methods of Selection of Quotient Digits During Digital Division," File No. 663, Department of Computer Science, University of Illinois, Urbana, Illinois, June 10, 1965.

5.2 "Methods of Selection of Quotient Digits During Digital Division"

5.2.1 Acknowledgments

The research on which this paper is based was conducted during 1963, while the author was on sabbatical leave from the University of Illinois as a Fulbright scholar at the Basser Computing Department of the University of Sydney, Australia, and subsequently at the University of Illinois during the academic year 1964-65. The author is grateful also to Dr. C. V. Freiman of the IBM Corporation for suggesting the mode of graphical presentation of Figures 1 and 5.

The first purpose of this paper is to present an indirect measure of the cost of selection of quotient digits during digital division. The class of division methods to which the measure is applicable was described by the author in an earlier paper[1] and involves redundancy in the representation of each digital position of the quotient. The redundancy increases with the ratio $\frac{n}{r-1}$, which is in the range $\frac{1}{2} \leq \frac{n}{r-1} \leq 1$, in which r is the radix and n defines the range of quotient digit values, which are integers of the form 0, $\pm$ 1, $\pm$ 2, ..., $\pm$ n. No redundancy exists if $\frac{n}{r-1} = \frac{1}{2}$.

The first example (Fig. 1) was chosen to be closely related to human methods of calculation and is <u>not</u> recommended for mechanization for a digital computer. The example is decimal (r = 10) with relatively little redundancy (n = 5).

Each step of the division can be described by the equation:

$$x_{j+1} = 10x_j - q_{j+1}d$$

in which j is the recursion index, x_j and x_{j+1} are partial remainders, x_0 is the dividend, d is the divisor, and q_{j+1} is the quotient digit. It is essential that the range restrictions on x_{j+1} and x_j be consistent; specifically,

$$|10x_j| \leq \frac{50}{9}|d|, \quad |x_{j+1}| \leq \frac{5}{9}|d|$$

Consider, as an example, with x_j and d positive, the choice of $q_{j+1} = 4$. Along the line $x_{j+1} = 10x_j - 4d$, note that $x_{j+1} = 0$ if $q_{j+1} = 4$. In order that x_{j+1} meet the range restriction $|x_{j+1}| \leq \frac{5}{9}d$, q_{j+1} must not be different from 4 outside the interval between the lines $10x_j = 4 + \frac{5}{9}d$ and $10x_j = 3 + \frac{4}{9}d$. Similarly q_{j+1} must not be different from 3 above the line $10x_j = 3 + \frac{5}{9}d$. Hence the choice of either $q_{j+1} = 4$ or of $q_{j+1} = 3$ may be made in the comparison interval between the

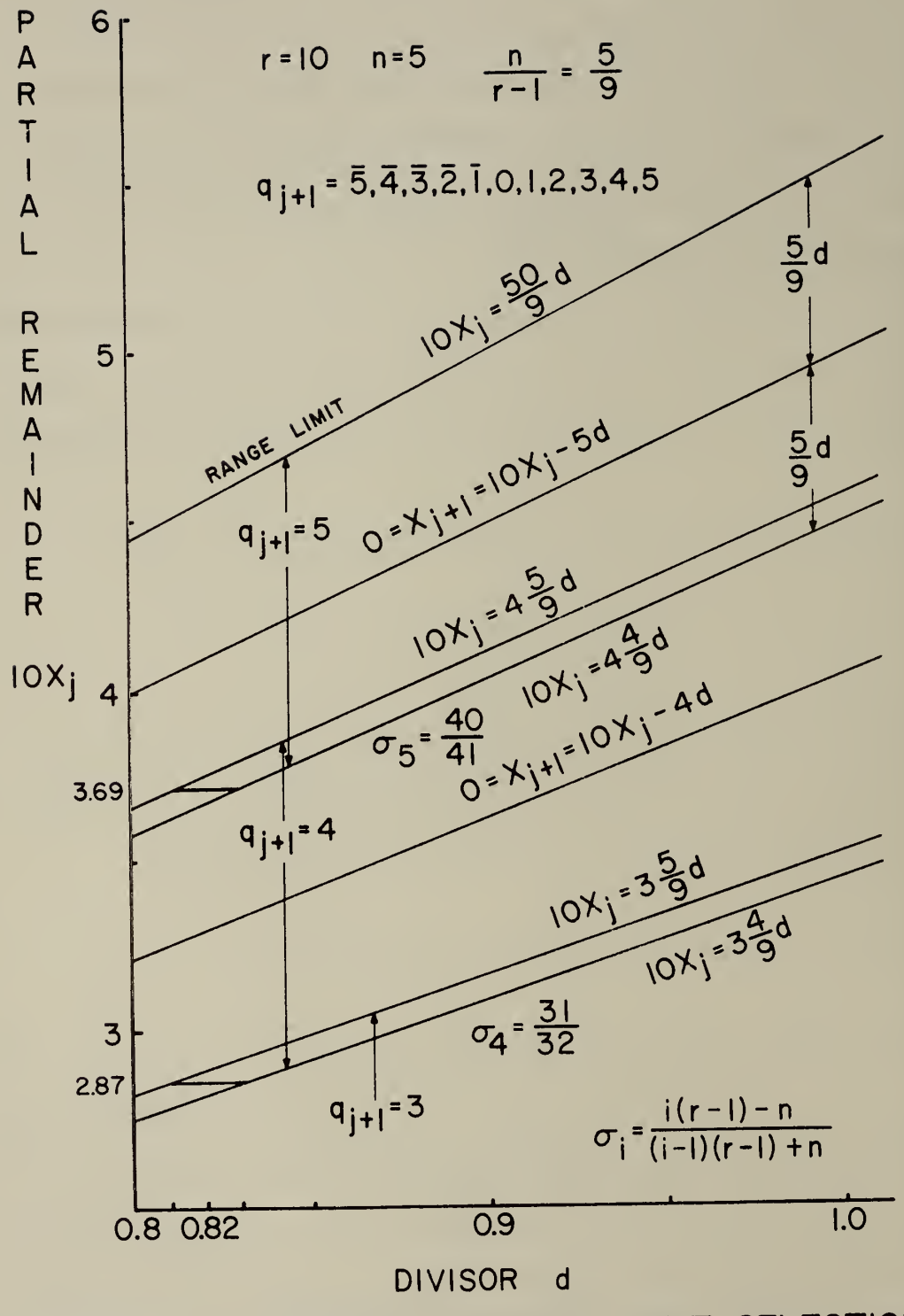


FIGURE 1. DECIMAL QUOTIENT DIGIT SELECTION

lines $10x_j = 3 + \frac{5}{9}d$ and $10x_j = 3 + \frac{4}{9}d$. The selection ratio σ_4 is the ratio of the slopes of this pair of lines. Specifically, $\sigma_4 = \frac{31}{32}$. More generally,

$$\sigma_i = \frac{i(r - 1) - n}{(i - 1)(r - 1) + n}$$

for the choice between $q_{j+1} = i$ and $q_{j+1} = i - 1$. The design problem in division is to choose comparison constants against which $10x_j$ is compared and to determine the divisor range for which each comparison constant is valid. For example, in Fig. 1, for $0.81 \leq d \leq 0.83025$, the choice $q_{j+1} = 5$ is made if $10x_j > 3.69$ and the choice $q_{j+1} = 4$ is made if $10x_j < 3.69$, without violating the range restriction on x_{j+1}. The selection ratio is a relative measure of the width of the divisor interval for which a single comparison constant is valid. The minimum number of divisor intervals can be calculated as follows. If $a \leq d \leq b$, find the smallest integer s_i such that $\sigma_i^{s_i} \leq \frac{a}{b}$. If, in Fig. 1, $a = \frac{1}{2}$ and $b = 1$, note that $(\frac{40}{41})^{28.1} \simeq \frac{1}{2}$; hence s_5 would be 29. For the procedure of Fig. 2, 41 divisor intervals would be necessary, 30 of width 0.01 covering the divisor range (0.495, 0.795), one for the interval (0.795, 0.81) and 10 intervals of width 0.02 for the divisor range (0.81, 1.01).

Two numerical examples of a decimal division with $n = 5$ are given in Fig. 2. The general procedure, valid for $d > 0.81$, is to choose a two-digit estimate $\hat{d}$ of the divisor such that the second digit of $\hat{d}$ is even. The comparison constants are then formed by multiplying $\hat{d}$ by $\pm\frac{1}{2}$, $\pm(1 + \frac{1}{2})$, ..., $\pm(4 + \frac{1}{2})$. The precision of the comparison constants is three decimal digits plus a sign digit. A three-digit estimate $10\hat{x}$ of the partial remainder (or dividend) is found, is compared with the list of comparison constants, and the appropriate quotient digit value is selected. The indicated addition or subtraction is then performed to full precision to form x_{j+1}, and $10x_{j+1}$ is formed by shifting. Note that the precision of $\hat{d}$, of the comparison constant list, and of $10\hat{x}_j$, are independent of the precisions of the divisor and dividend.

FOR TWO DIVISORS

0.81001 and 0.82999

$\hat{d} = 0.82$

	$q_{j+1} = 5$
$4\frac{1}{2}\,\hat{d} = 3.69$	
$3\frac{1}{2}\,\hat{d} = 2.87$	$q_{j+1} = 4$
$2\frac{1}{2}\,\hat{d} = 2.05$	$q_{j+1} = 3$
$1\frac{1}{2}\,\hat{d} = 1.23$	$q_{j+1} = 2$
$\frac{1}{2}\,\hat{d} = 0.41$	$q_{j+1} = 1$
$-\frac{1}{2}\,\hat{d} = -0.41$	$q_{j+1} = 0$
$-1\frac{1}{2}\,\hat{d} = -1.23$	$q_{j+1} = \bar{1}$
$-2\frac{1}{2}\,\hat{d} = -2.05$	$q_{j+1} = \bar{2}$
$-3\frac{1}{2}\,\hat{d} = -2.87$	$q_{j+1} = \bar{3}$
$-4\frac{1}{2}\,\hat{d} = -3.69$	$q_{j+1} = \bar{4}$
	$q_{j+1} = \bar{5}$

$.45\bar{3}\bar{4}5$

$.81001 \overline{)\ .3617099655}$

-3.24004

$.377059655$

-4.05005

$-.27945345$

$+2.43003$

$-.3645045$

$+3.24004$

$-.405005$

$+4.05005$

$.00000$

$10\hat{x}_0 = 3.61 \quad q_1 = 4$

$-4d$

$10\hat{x}_1 = 3.77 \quad q_2 = 5$

$-5d$

$10\hat{x}_2 = -2.79 \quad q_3 = \bar{3}$

$+3d$

$10\hat{x}_3 = -3.64 \quad q_4 = \bar{4}$

$+4d$

$10\hat{x}_4 = -4.05 \quad q_5 = \bar{5}$

$+5d$

$.45\bar{3}\bar{4}5 = .44655$

$.5\bar{5}\bar{3}\bar{5}5$

$.82999 \overline{)\ .3706320345}$

-4.14995

$-.443629655$

$+4.14995$

$-.28634655$

$+.248997$

$-.3734955$

$+4.14995$

$+.414995$

-4.14995

$.00000$

$10\hat{x}_0 = 3.70 \quad q_1 = 5$

$-5d$

$10\hat{x}_1 = -4.43 \quad q_2 = \bar{5}$

$+5d$

$10\hat{x}_2 = -2.86 \quad q_3 = \bar{3}$

$+3d$

$10\hat{x}_3 = -3.73 \quad q_4 = \bar{5}$

$+5d$

$10\hat{x}_4 = 4.14 \quad q_5 = 5$

$-5d$

$.5\bar{5}\bar{3}\bar{5}5 = .44655$

FIGURE 2. DECIMAL NUMERICAL EXAMPLES

The most difficult choice is between the two largest values of the quotient digit magnitudes, namely $|q_{j+1}| = n$ and $|q_{j+1}| = n - 1$. The behavior of the selection ratio σ_n for this choice is plotted in Fig. 3. The binary SRT division[2] ($r = 2$, $n = 1$) is valid for a divisor range $\frac{1}{2} \leq |d| \leq \infty$; hence $\sigma = 0$. The remaining lines, in ascending order, correspond to a minimum of 1, 2, 4, 8, and 20 divisor intervals for binary normalization of the divisor ($\frac{1}{2} \leq |d| \leq 1$). The line $\sigma = 1$ corresponds to no redundancy in the quotient digit representation, indicating that partial remainder and divisor must be compared to the full precision of the divisor.

The second purpose of this paper is to observe that the mechanism for selection of quotient digit values is simply a limited precision model of the full precision division. The consequences of this observation are that the precedures in the model need bear no relationship to conventional division procedures. Some examples are:

1. Present practice is the logical equivalent of a table look-up procedure.
2. The procedure of Fig. 2.
3. The procedure illustrated in Fig. 4 for radix 4, $n = 2$, is that of logically forming the approximate reciprocal of the divisor[3] and multiplying by the partial remainder. The value of the quotient digit is found by rounding the product to the nearest integer value.
4. An arithmetic unit with four borrow-save subtractors would provide a relatively high multiplication speed, radix 256. The division model with $r = 256$, $n = 170$ would require 12 bits + sign for the divisor and 13 bits + sign for the partial remainder. The model division could be done in four steps, radix 4, as in Fig. 4, in,

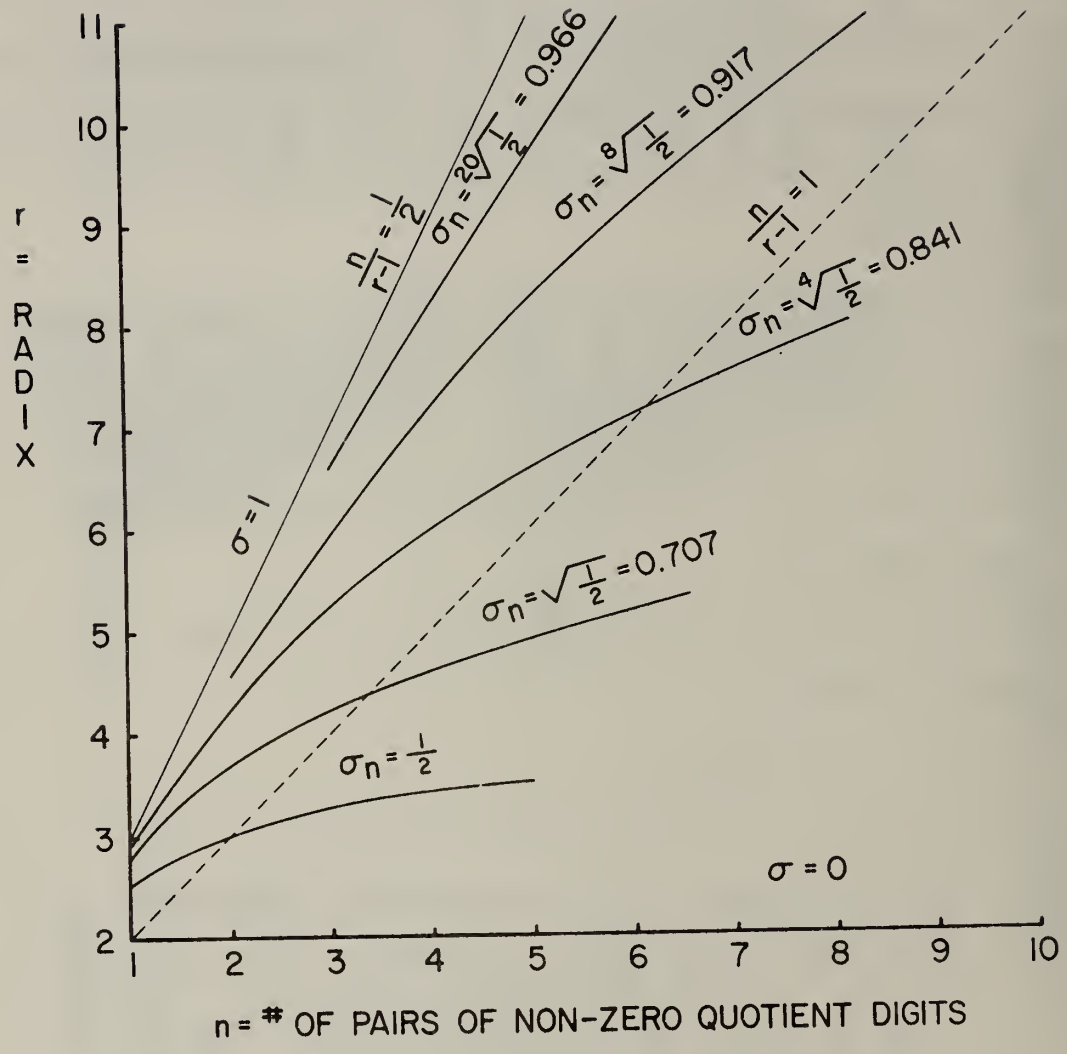
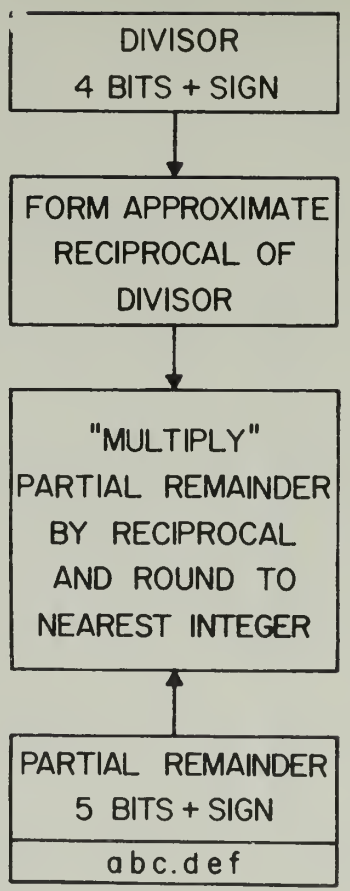


FIGURE 3. BEHAVIOR OF σ_n FOR VARIOUS DIVISION METHODS



RECIPROCAL FORMATION	"MULTIPLICATION"
$2(\frac{1}{2},\frac{9}{16}) = (1,\frac{9}{8})$	bcd.e
$(2-\frac{1}{4})(\frac{9}{16},\frac{5}{8}) = (\frac{63}{64},\frac{35}{32})$	bcd.ef − .bcdef
$(2-\frac{1}{2})(\frac{5}{8},\frac{3}{4}) = (\frac{15}{16},\frac{9}{8})$	bcd.e −b.cde
$(1+\frac{1}{4})(\frac{3}{4},\frac{7}{8}) = (\frac{15}{16},\frac{35}{32})$	abc.de +a.bcde
$(1+\frac{1}{8})(\frac{7}{8},\frac{15}{16}) = (\frac{63}{64},\frac{135}{128})$	abc.d + .abcd
$1(\frac{15}{16},1) = (\frac{15}{16},1)$	abc.d

$$\sigma_2(\tfrac{9}{8}) = (\tfrac{4}{5})(\tfrac{9}{8}) = \tfrac{9}{10} < \tfrac{15}{16}$$

FIGURE 4. QUOTIENT DIGIT SELECTION PROCEDURE FOR r=4, n=2

say, the character processor, with each radix 4 digit controlling a divisor multiple input to one borrow-save subtractor.

5. Figure 5 is a graphical verification of the validity of one case of the theory of segmented division of Metropolis and Ashenhurst.[4] Here the "limited precision" model is a binary arithmetic unit with a normalized single-precision (m digits + sign) divisor, a double-precision (2m digits + sign) dividend, a quotient of m digits + sign. The "full-precision" division is a multiprecision division with both divisor and dividend consisting of as many m + 1 digit segments as are desired. The one segment approximation $\hat{d}$ is rounded so that the multiprecision divisor d is in the range $\hat{d} - \frac{1}{2}(2^{-m}) \leq d < \hat{d} + \frac{1}{2}(2^{-m})$, if $d > 0$. The "model" division is such that the points $\hat{d}(2^m - 1)$, $\hat{d}(2^m - 2)$, $\hat{d}(2^m - 3)$, etc., are precisely delineated by the values of the quotient digit generated. In the terminology of preceding sections, these points are comparison constants. For example, if $d < \hat{d}$ and the model quotient digit is $2^m - 2$, then $\hat{d}(2^m - 2)$ is the comparison constant. For the case illustrated in Fig. 5, a model quotient digit value of $2^m - 2$ indicates that $\hat{d}(2^m - 2) \leq 2^m x_j < \hat{d}(2^m - 1)$; hence $q_{j+1} = 2^m - 1$. It remains to verify that, in the worst case, the divisor range $\hat{d}(1 - \sigma_i)$ for which the comparison constant $\hat{d}(2^m - i - 1)$ is valid, exceeds the error $\hat{d} - d$. The range of validity is least for $\hat{d}$ minimum, and for σ_i maximum; hence $\frac{1}{2}(1 - \alpha_n) = \frac{1}{2}(\frac{1}{2^m - 1})$ is the smallest value. Since this

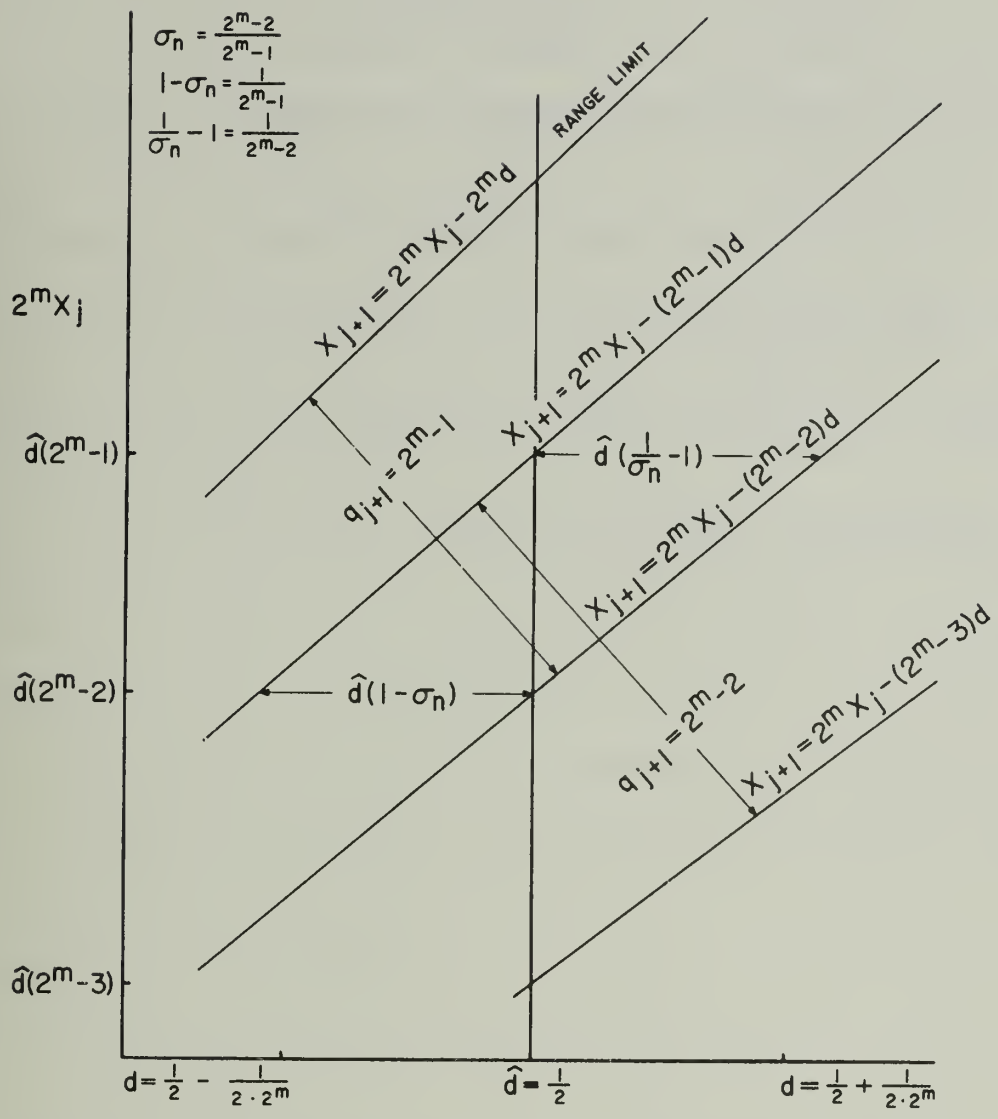


FIGURE 5. WORST CASE SELECTION FOR $r = 2^m$, $n = 2^m - 1$

exceeds the error $\hat{d} - d = \frac{1}{2}(\frac{1}{2^m})$, the validity of the procedure is established for this case. Similarly, use of $\hat{d}(2^m - 1)$ as a comparison constant is valid for the divisor range of width $\hat{d}(\frac{1}{\sigma_n} - 1) = \frac{1}{2}(\frac{1}{2^m - 2}) > \frac{1}{2}(\frac{1}{2^m})$ when $d \geq \hat{d}$.

It is the author's opinion that the concept of limited-precision modeling presents many possibilities for versatility of structure of future computers. Of importance are the facts that the precision of the model is independent of the full precision of the arithmetic unit and the fact that the control complexity is confined to the model, which generates simple microprogram instructions for the full-precision unit. Thus, the number defining full precision can be changed in discrete modular steps; the only information needed by the model is the number of major cycles required. Preliminary investigations indicate that other trial-and-error computation procedures, such as square rooting,[5] can also be controlled by a limited-precision model.

BIBLIOGRAPHY

[1] Robertson, J. E. "A New Class of Digital Division Methods," IRE Trans. on Electronic Computers, Vol. EC-7, pp. 218-222; September, 1958.

[2] Freiman, C. V. "Statistical Analysis of Certain Binary Division Algorithms," Proc. IRE, Vol. 49, pp. 91-103; January, 1961.

[3] Wallace, C. S. "A Suggestion for a Fast Multiplier," IEEE Trans. on Electronic Computers, Vol. EC-13, No. 1, p. 14, February, 1964.

[4] Metropolis, N. and R. L. Ashenhurst. "Basic Operations in an Unnormalized Arithmetic System," IEEE Trans. on Electronic Computers, Vol. EC-12, No. 5, pp. 896-904, December, 1963.

[5] Metze, G. A. "Minimal Square Rooting," IEEE Trans. on Electronic Computers, Vol. EC-14, No. 2, pp. 181-185, April, 1965.

6. ILLIAC IV

6.1 Summary of the Proposed Program

This program consists in the design, fabrication, installation, and use of a large scale, highly parallel digital system. This system, it is believed, will through the employment of a parallel array of computing elements produce significant increases in the solution speed of many problems currently being handled on conventional sequential machines but more importantly will encourage the tackling of entirely new areas of problems and these in many cases by entirely new means.

The first phase of the program, an eight-month effort, will be conducted with the cooperation of three industrial organizations to be selected by competitive bidding. This phase will result in the development of a detailed system design optimized on the basis of hardware and software considerations and preliminary analytical efforts conducted jointly with potential users of the system. Within two months of program start, the University will prepare a bid set for a five-month design study to be awarded concurrently to three industrial organizations. Only organizations possessing the capability to manufacture, install, and maintain the system to be designed during this phase will be considered as candidates for study award.

This system will be based on the principles of the parallel machine designs which have preceded it but will possess capabilities exceeding its predecessors in that individual processing elements will possess greater local autonomy (in the sense of instruction interpretation and address modification). It is also desired that the system possess variable precision. This system will also incorporate features to facilitate the interaction between the system and its users both in the programming phases preliminary to production runs and to facilitate through consoles with dialogue capabilities the system-user iteration.

The second phase lasting two years will see the fabrication and installation of the system. The final reports of the three companies having received first phase awards will serve as proposals for this phase. Although this by no means excludes the solicitation of proposals from companies which

did not receive phase 1 awards. The University will during this period develop both general and special purpose software so that the system can receive productive employment immediately upon installation at the University. This work will include assemblers and compilers at an appropriate level as discussed in Section 6.3 and analytical and programming efforts in several of the application areas described in Section 6.3.4

This proposal is for phases 1 and 2 of the proposed program. However, since it is the third phase which is the overall objective of the effort, we summarize phase 3 here with a more detailed discussion given in Section 6.2: phase 3 will involve the use of this system in a broad spectrum of application areas. The users will be drawn from distinguished investigators in the academic world, industry, and government both through a visitor's program of international scope and the employment of narrow and broad-band remote consoles. These investigators will include researchers in numerical weather forecasting, phased-array signal processing, hydrodynamic calculations, matrix and linear programming calculations, partial differential equations, neural-network simulation, heuristic programming and machine simulation and design.

6.2 Purpose and Objectives of the Proposed Program

The past decade of data processing experience has established both quantitative and qualitative limits of sequential digital systems. Among the more serious quantitative limitations is the lack of sufficient speed to perform signal processing functions for multichannel sensor arrays such as phased-array radars and phased-array seismometers. It is clear that such sensor arrays are the only means of overcoming the limitations of individual sensors in a manner highly analogous to the use of parallel processors to overcome sequential speed limitations. In the use of parallelism, sensor technology currently is more advanced than data processing technology.

Several classes of calculations having as their common denominator the integration of partial differential equations have experienced limitations of such a severe nature as to substantially preclude usefulness, for example, a long-range numerical weather forecasting. A seven-day forecast if carried out to a reasonable degree of precision, requires more than seven days of calculation; hydrodynamic and energy transfer calculations which arise in simulation of nuclear devices requires too much running time to make these potentially highly useful results economically feasible.

It is anticipated that this system will overcome the aforementioned obstacles and perhaps more importantly permit a new class of calculations to be performed in which the parallel processor although wholly digital in its precision is used as an analogy machine in image processing, neural-network simulation and machine system design and simulation.

6.3 Technical Details

6.3.1 System Organization

The overall system organization is illustrated in Figure 6.1 The system central control (CC) provides instruction sequences to the processing element array. These sequences are stored in the central memory (CEM). Data is transferred from the central memory to the process element memory (PEM) through the memory transfer buffer. Two classes of peripheral equipment are distinguished: those which have direct access to processing elements and processing element memory and those to which access is provided through a system interface with the University of Illinois Computing Center. In the former category are, for example, multichannel sensors with direct entry on a per channel basis into individual processing elements, possibly a large disk file with individual tracks having mutual access with individual PE memories and wide band T.V. displays which display directly from PE registers or memory. In the latter category are those equipments already peripheral to the University of Illinois computing complex such as tapes, disks, card readers, printers, plotters, and narrow band remote consoles (teletype and telephone line speeds). The interface will operate in a main memory to main memory high speed parallel interface mode and permit full advantage to be made of the extensive existing peripheral and remote console equipment complement.

It is anticipated that the system to be developed will depart extensively from prior designs particularly in that provision will be made for multiprocessing and a far greater degree of local processing control both in local address modification and in local instruction modification. The manner in which these extended capabilities will be secured in indicated below.

Figure 6.2 indicates the fashion in which the network can be made to operate on four unrelated problems simultaneously. Central memory provides instructions to an instruction stack under central control. Each instruction specifies a requirement for one, two, three, or four network quadrants. These requirements are processed and queued in sequencer request logic and ultimately the instructions transferred to one or more of the four sequencers for execution in the network. Note that the connections between sequencers and network are fixed, that is, not switched. The switching occurs in the sensor request logic and is simply a four-way switch of a partially decoded instruction. Switching on this level can be implemented

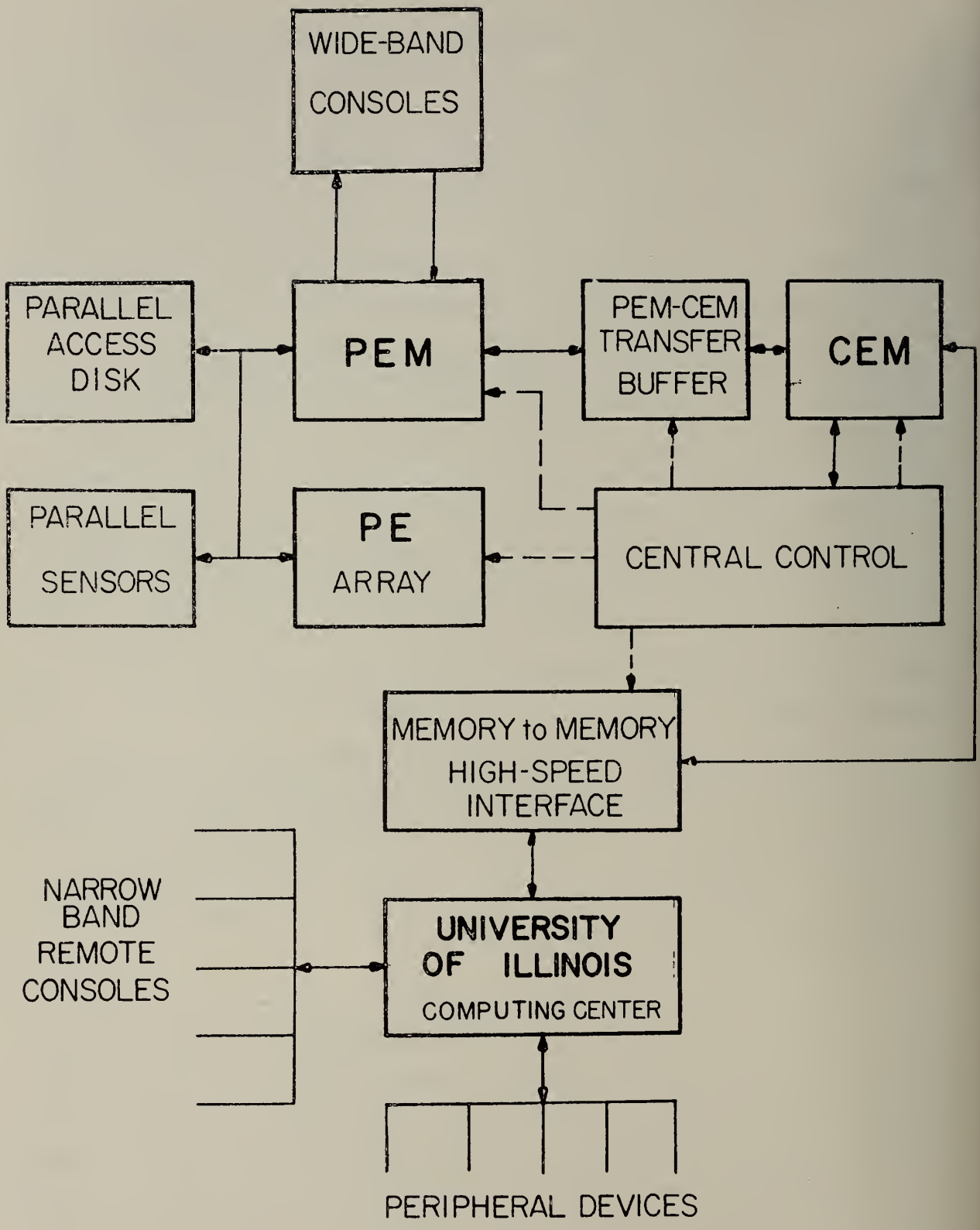


Figure 6.1. System Organization

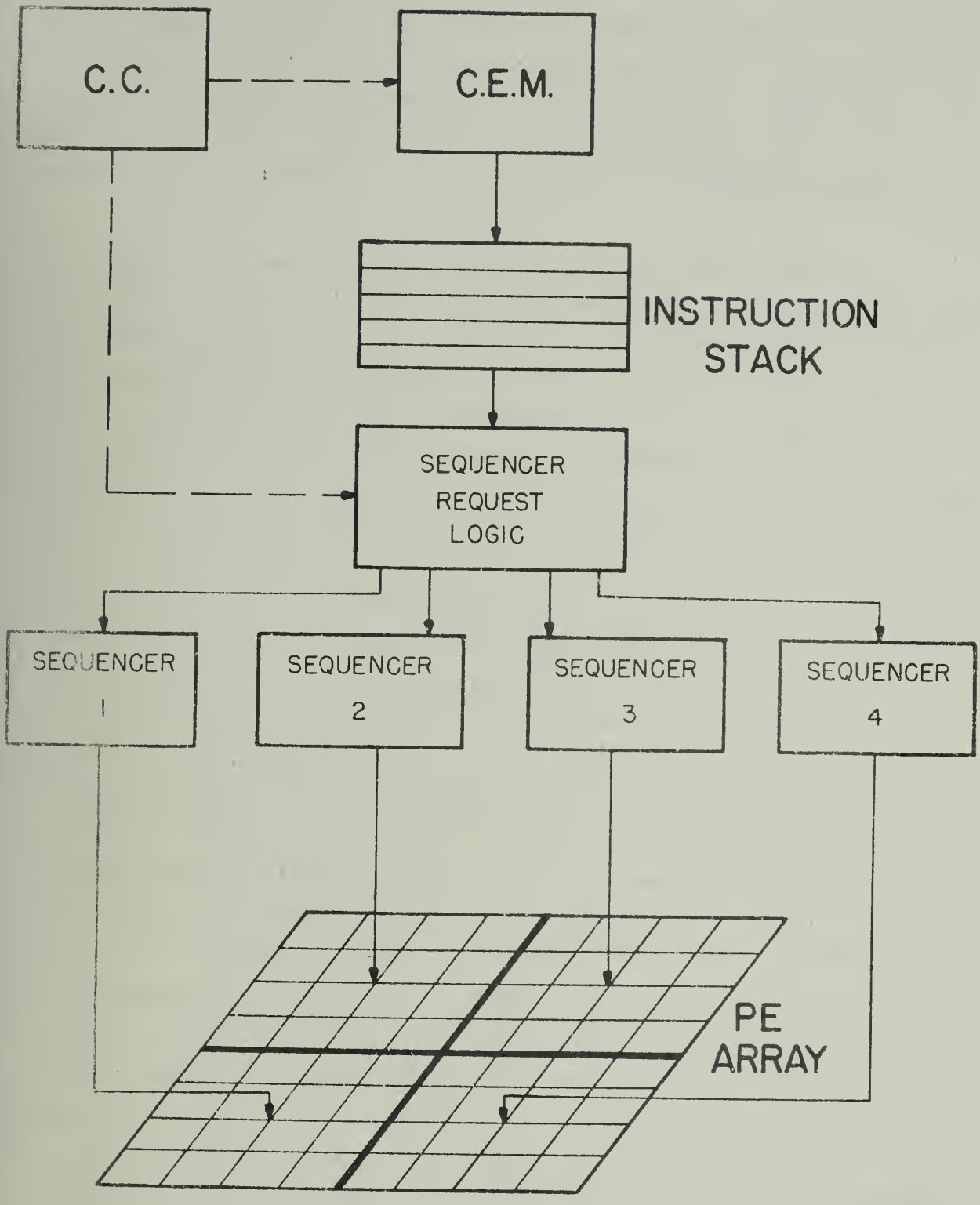


Figure 6.2. Multiprocessing in the Network

with a reasonable amount of hardware while, of course, switching between sequencer and processing element array would involve the switching of the numerous control lines connecting the sequencers and processing elements. The responsibility for the execution of programs in such a manner so that inter- and intra-program dependencies are not violated will be divided in an appropriate manner between the central control hardware and the program stored in central memory.

Previous parallel network designs specified only one operand address to the entire network and provided the entire network with but a single instruction at a given time the only local choice being whether or not to perform the instruction based on a comparison of internal mode values and mode specifications in the instruction. It is anticipated that the proposed system will incorporate features to permit both local address modification and instruction modification. This is illustrated in Figure 6.3 The central control will specify to all of the processing elements (that is those under the control of a given sequencer (in no way violating the multi-processing capability described above) the high order bits of the processing element operand address. Each processing elements will possess a set of multipurpose registers one of whose functions will be to insert into the address register the low-order digits of the processing element operand address. Thus, effectively central control will specify to each processing element a block address. This addressing hardware (block address) can be shared by all of the PE's for economy. The individual processing element will then furnish the remaining bits required to specify a unique address within this block. The precise division of bits between central and local will be determined during the course of the phase 1 study.

In an analogous manner central control will furnish to all of the processing elements some of the control signals required for instruction execution in the processing element. The remainder of the signals will be provided locally as determined by the contents of PE registers. For example, some of the bits which may be provided locally are accumulator true or complement, operand true or complement, result sign positive or negative, add or subtract, operand offset or no offset, operand offset by variable amount, operand and mask or no mask through accumulator, etc.

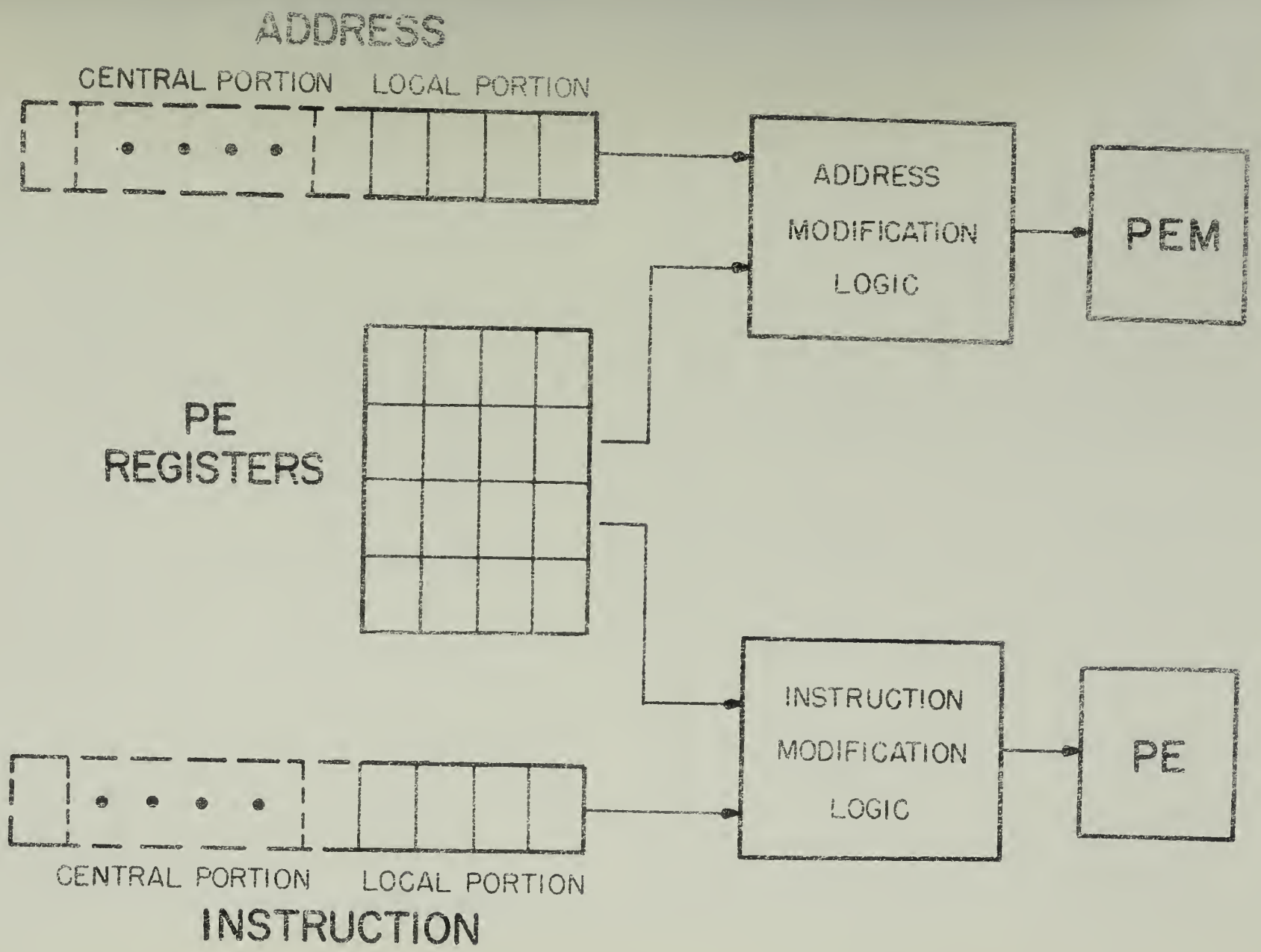


Figure 6.3. Local Control

It has been observed that some problems such as mesh calculations require high precision while others such as visual image processing require only two to five bits of precision. To accommodate such diversity efficiently it is anticipated that the network will be designed to possess variable precision. This can be accomplished as shown in Figure 6.4. For simplicity of presentation this illustration uses specific numbers. These are, however, of no particular significance. A group of four bit PE's can be viewed as connected in gang fashion directly to a full 16-bit parallel arithmetic and logic unit. In this mode the performance of 16-bit instructions will proceed at high speed. If, however, it is desired to operate with lower precision, for example four bits, the parallel arithmetic unit is designed so that the appropriate carries can be disabled yielding four high speed four-bit logic and arithmetic units. For some reason it appears easier to view it conceptually in the manner described, as a partitioning of a long word unit into many short word units, as a matter of practical design the point of view is the opposite, that is, the design of a highly efficient short word unit with the minimal additional hardware to permit its ganging into long word units.

6.3.2 Hardware

No component or low-level subsystem will be undertaken specifically as a part of this program. The participating industrial organizations with the concurrence of the University will make the selection of implementation hardware from among units already in existence or in advanced stages of development. Some current thoughts on implementation follow. It is readily seen that all system speeds depend upon PEM speed. Currently it would appear as though half microsecond (cycle time) 20 mil cores will be available economically in quantity within the time scale of this program. Not to be entirely overlooked are plated wire, magnetic thin films and laminated ferrites. As for active elements it is difficult to justify a choice other then integrated circuits for most of the active logic and flipflop registers. In register stacks and buffers which may operate at somewhat slower speed argument can be made for the use of metal oxide semiconductors on the basis of economy.

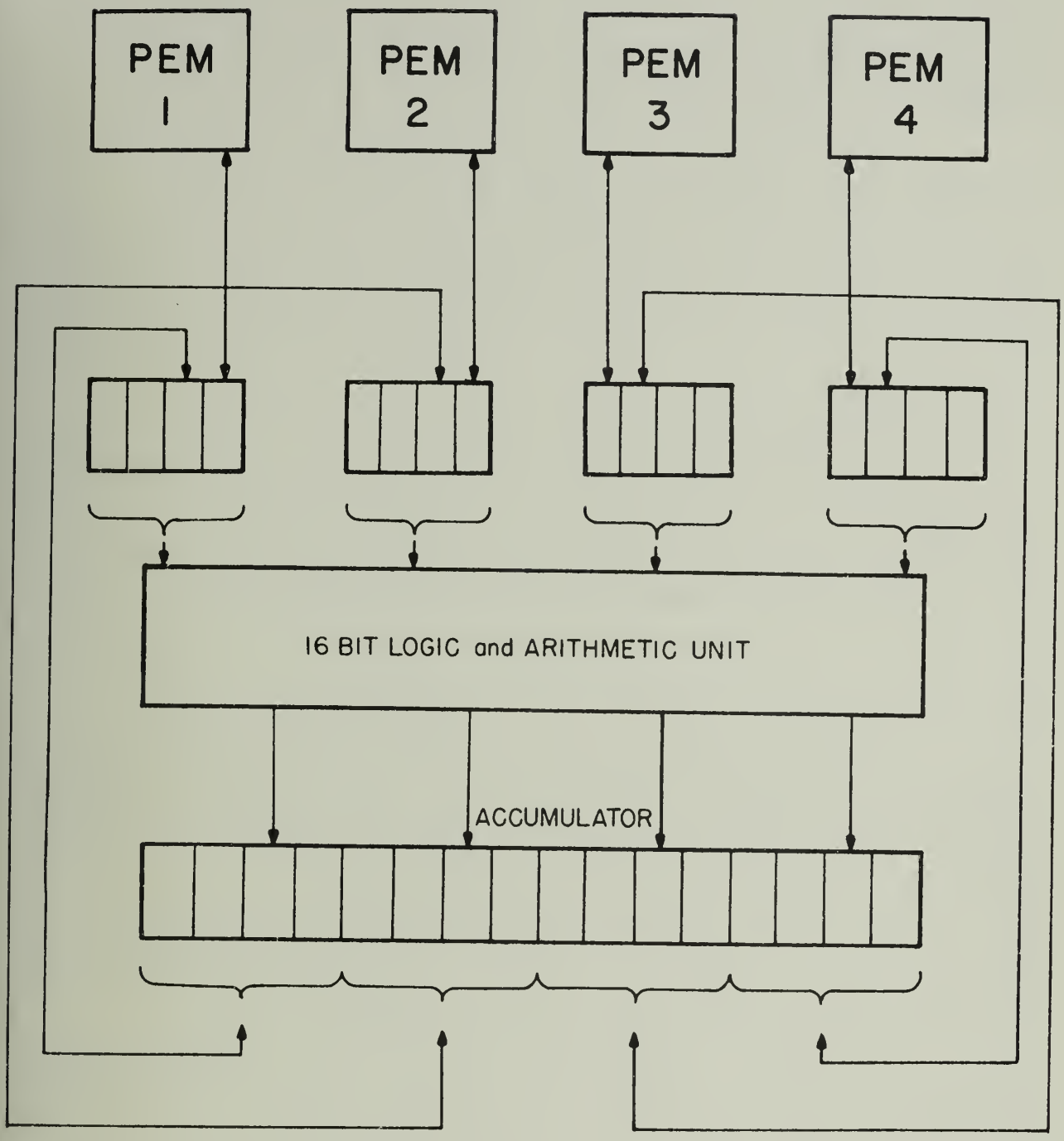


Figure 6.4. Variable Precision

The proposed system will utilize conventional data processing peripheral storage devices through its interface with the University Computing Center. The phase 1 study may demonstrate a need for a special disk modification for direct connection to the processing element array.

The display console will utilize the best available video display equipment possibly provided with background projection. The use of stereo read-out, curve and surface generation from parametric specification, direct camera hook-ups (that is a monitor mode) and hard copy auxiliaries will be determined during the course of the phase 1 study. Dialogue capability will be provided through the use of light-pen and console keys if no superior techniques are available.

To summarize, since one of the main goals of this investigation is to gain experience in the use of a parallel network computer, to get to know their potentialities and limitations, and since there exists no established know-how as to what features should or should not be provided either by hardware or software, we propose to adopt the following guidelines:

1) A rich order-code without ad hoc limitations is to be provided

2) Local autonomy, i.e., the ability of a PE to interpret an instruction depending on its present state, is to be greatly encouraged and limited only by cost-effectiveness considerations. In particular, any PE should be able to change any instruction into a no-operation

3) In order to attain a completely modular and expandable computer system, the instructions should be independent of the number of PE's and possibly also on the size of the central memory

4) Variable length data structures are to be provided, but the instructions should be independent of the number of bits of the operand (so that different PE's can perform the same operation on different types of operands).

5) Modification of an address referring to the PE memories should be performed both by the central control and by each PE individually. Both the CC and each PE should have a number of index registers which can be referred to in an instruction. This provides a very convenient means for multiple indexing.

6.3.3 Software

One of the current serious deterrents to cost-effectiveness of parallel machines is the lack of depth and availability of software. It is one of the principle objectives of this program to develop compilers and operating systems that will bring programming costs for parallel systems into line with those for conventional systems.

The essential feature of process or problem-oriented languages is that they must be well suited to the specification of the process and independent of machine characteristics. At the current stage of development, however, the process, its descriptive language and the machine organization are not and should not be separable.

This problem has several facets. First and least significant, algorithms are not available at present to translate processes as specified in existing languages into programs for parallel machines. Second, the parallel processes are generally most naturally defined in a language which reflects the parallel aspects of the problem. This is particularly true for processes which involve the local or global geometrical and topological properties associated with data arrays. For example, sequential machines in the program for the conventional relaxation process for the Laplace Equation over a two-dimensional grid includes a nested pair of "DO" loops for running through rows and columns of the grid. When this grid is mapped onto a two-dimensional parallel network, these "DO" loops are eliminated. It is then convenient to describe the relaxation process as averaging the north, south, east, and west grid points. The third difficulty with conventional languages is that they do not provide enough information about the process for a translator to be efficient.

The following sections deal with some of the problems of software in some detail.

6.3.3.1 Programming Languages

A number of programming languages will be provided, ranging from an assembly language which is essentially in 1:1 correspondence with machine language to high level procedure -- and problem-oriented languages where the compiler and/or system monitor will assign the individual processing elements

to the tasks to be performed, and split a computation which requires more than the available number of PE's into separate jobs which will be run in a serial fashion.

In this hierarchy of languages ease of programming will be inversely proportional to the attainable efficiency of the object code. In order to optimize critical parts of a program, such as inner loops, it should be possible at any time to change from any language to another one which is lower in the hierarchy, in particular to machine language.

No existing programming language allows for a sufficient specification of the parallelism inherent in a computation. Even recent suggestions as, e.g., in[1,2], to introduce declarations like DO TOGETHER and HOLD to indicate that certain tasks can be computed in parallel, but the computation following these has to await completion of all tasks computed in parallel, does not seem to be sufficiently general for our purpose.

The languages envisioned here for a parallel network computer will allow and encourage the user to segment his program into small self-contained parts, with an explicit specification of the logical dependencies between the parts. Inside a complicated loop-structure, e.g., such a specification might say that program part one can be entered for the nth time if and only if part two has been executed f(n) times.

The inclusion of very general features for specifying parallelism will make demands of an entirely new nature on compilers and systems programs, particularly in connection with the assignment of PE's or blocks of PE's to given tasks. This creates problems which go far beyond those currently dealt with in connection with storage allocation (in itself one of the least well understood aspects of systems programming), which will make the task of providing system programs for a parallel network computer a problem of research rather than development.

One direct approach to the language problem for parallel machines is to expand an Algol-like language so as to provide the terms necessary to specify network operations. The programmer is thereby provided the means to define the process in a way natural to the machine organization.

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1. Needleman, N. R. and C. A. Irvine, "Path Finder, A Source Code Analysis Program for the Multiprocessor Environment", Western Data Processing Center, UCLA (to be published).

2. Opler, A., "Procedure-Oriented Language Statements to Facilitate Parallel Processing", Comm. ACM, Vol. 8, No. 5, May 1965, pp. 306-307.

Some of the required extensions would be along the following lines.

The format of PE data words must be defined both as to range and type. The format may be defined with a statement:

FORMAT n1, n2

where n1 and n2 are unsigned integers which indicate the number of bits in the mantissa and exponent. The range may be defined with a statement such as

RANGE n1, n2

where n1 and n2 are unsigned integers and give the upper and lower bounds. To define integer variables in the PE array a statement such as

PE INTEGER Vℓ.

is required and to define a real variable

PE REAL A.

Thus, for example, to define a five-bit integer in the PE array we write:

PE INTEGER Vℓ RANGE 1, 32.

To provide array storage allocation write

PE ARRAY Vℓ (n1, n2)

where n1 and n2 give the upper and lower bounds of a single dimension array. For example,

REAL PE ARRAY A (1, 9) FORMAT 28, 8

defines an array with nine 36-bit words.

A configuration statement

PE TOPOLOGY S

is necessary to define the topology S where S is one of planar, linear, cylindrical, toroidal, spherical.

It is sometimes necessary to identify a particular PE or group of PE's by coordinates, thus PE (I, J) means the PE in row I, J. I and J can be expressions. Thus PE (1, 1) is the upper left PE and A (PE (1, 1)) means the variable A in PE (1, 1).

It is also necessary to have relative PE labels, that is, labels of PE's relative to specific or base PE's. Thus N, S, E, W, NE, NW, SE, SW, and B are relative labels standing for north, south, etc., and B for base. Examples of the use of these labels are A (S), I (NE) where A and I are PE variables.

Geometric control on prior designs has been used to control PE's according to externally derived patterns. These patterns can be expressed by a statement such as

PE INDEX V1 = V2 STEP V3 UNTIL V4.

where V1, V2, V3 and V4 are expressions, and which have the same meaning as in sequential Algol except that a PE INDEX results (ordinarily) in an activation of geometric control register rather than the performance of a loop. As an example

```
PE INDEX I = 1 STEP 2 UNTIL P
         J = 1 STEP 1 UNTIL Q
         M = 0
M (PE (I, J)) = 1
```

will result in the PE INTEGER, M being set to 1 in alternate rows.

It is also necessary to provide for tests of PE status including branching on existence or nonexistence of PE's satisfying a Boolean condition. Thus, IF ANY and IF NO statements might be used. For example

IF ANY M = 1 A = 0 THEN K = M(N)

means if there are any PE's for which the PE INTEGER (mode) M = 1 or the real variable A = 0 then set the PE INTEGER, K, of all PE's equal to the value of M in the North PE.

Sequential variables if restricted to Central Control permit mixed expressions of the following type:

IF M = 3 AND Y = 0 THEN X(B) = X(N)

means if the mode of a PE is 3 and Y = 0 where Y is a sequential variable, then set X of the PE to the value of X in the North PE.

```
IF M(N) = 1 and K(B) = 2 THEN X(N) = Y
```

where X is a PE variable and Y a sequential variable, means if the mode (M) of the North PE is 1 and the mode (K) of the PE itself is 2, then broadcast Y to the North PE and store it in location X.

A further example is

```
A(B, 1) = (A(B, 2) + A(B, 4) + A(N, 6) + A(S, 8)) / 4
```

which occurs in the nine point star for the Laplace Equation, while

```
PE INDEX N5 = 1 STEP 1 UNTIL Q
PE TOPOLOGY TOROIDAL
FOR N3 = 1 STEP 1 UNTIL Q DO
BEGIN
AIK = A (PE (1, N3), N4)
CK = AIK / AKK
IF (1 = ALROW (N3)) THEN
A (PE (1, N5), N3) = A (PE (1, N5), N3) -
                     A (PE (1, N5), N4) * CK
END
```

eliminates subdiagonal elements in Gauss elimination with the pivotal element in row N4, and ALROW defining subdiagonal rows.

These examples make it clear that syntax tables for such a language would be long if it were necessary to define all allowable combinations of PE and sequential variables.

6.3.3.2 Multiprogramming

Since the number of PE's that may be actively used in any computation or part of a computation is likely to vary considerably, one should not have to commit all PE's at all times to a particular program and have a large part of them be inactive.

Two solutions for circumventing such an inefficient use of the PE network suggest themselves:

1) It is desirable to provide for a high-speed interface between the central memory and control and a conventional high-speed computer in order to permit computations which exhibit no parallelism at all to be performed on line without blocking the PE network.

2) It should be possible to partition the PE network into a (small, for economy reasons) number of blocks, each of which can execute a different program in central memory. This will allow a multiprogrammed operation of the computer which is simultaneous rather than time-shared.

6.3.3.3 Compiling on a Parallel Network Computer

Compiling is traditionally a serial process, involving repeated scanning of the source language string forwards or possibly backwards. Therefore, if one intends to use existing techniques, one would probably compile programs for the parallel network computer on a conventional computer, which is either on- or off-line. If compiling speed is at a premium, this computer should be on-line, because certain operations like table-look-up, which occur very frequently in compiling, can be done extremely fast on a parallel network.

However, it seems possible to devise a programming language satisfying certain constraints which can be compiled extremely rapidly on a parallel network computer, making full use of all PE's. We suggest a language in which statements can be compiled independently of each other (except for certain simple operations like inserting absolute addresses) and the statements can be divided into a few categories (say arithmetic statements, transfer statements, etc.) satisfying the following property: all statements within one category can be compiled not only by the same routine, but also by essentially the same sequence of instructions.

Compilation would proceed by selecting all statements of a category from the source program, assign one to each PE, then execute the compiling routine for that particular category of statements. Then the same procedure would be repeated on the statements of some other category, until the whole program has been compiled.

Undoubtedly the programming language envisioned here will be restrictive in certain respects, but we believe that it can still be made to be useful. The restriction that all statements within one category can be compiled by the same sequence of instructions is to be taken modulo the degree of local autonomy of the PE's. In particular, since every instruction can be changed locally to a no-operation, it does by no means imply that all statements are equally long.

6.3.4 Applications

As with most technological advances we expect that the most important consequences of parallel computation will be none of the more or less obvious ones described below. However, these foreseeable applications present a sufficiently rewarding future for parallel systems to warrant their description. This emphasis will in fact be maintained throughout all phases of the proposed program; that is, in addition to pursuing the application areas described below, a continuing effort will be made to find new approaches and new application areas.

6.3.4.1 Differential Equations

The importance of differential equations rests on the vast number of natural phenomena which they describe. Atmospheric flow, hydrodynamics, the propagation of shock waves, diffusion, and behavior of electro-magnetic waves are all governed by basic partial differential equations. Ordinary differential equations, of course, govern a spectrum ranging from classical mechanics to nonlinear circuits. It is certainly no wonder that from the start of mathematical calculations several centuries ago through today the principal subject of scientific calculations is the numerical solutions of differential equations.

It is in precisely this area that the applicability of parallel processing has been most amply demonstrated. A review of the standard finite difference methods available to numerical analysts shows that they are almost all parallel in nature or can with simple manipulation be made so and thus lend themselves in a very natural way to execution within a parallel network. In particular, for the most important case, where a numerical method involves

solution over a grid covering an area of interest of a partial differential equation, the grid itself and the operations to be performed thereon are analogous to the geometry and operation of a parallel network. Furthermore, the versatility of a network such as the proposed array of processing elements further extends this applicability to situations involving, for example, cylindrical, spherical, etc., geometries in three, four, or higher dimensions. Certain other numerical techniques such as Monte Carlo, direct methods (Green's functions) heretofore neglected due to the lack of sufficient computational force appear to be quite efficient for parallel networks.

The integration of ordinary differential equations by any standard method is an entirely serial process. In "Parallel Methods for Integrating Ordinary Differential Equations," by J. Nievergelt (Comm. ACM, Vol. 7, No. 12, December, 1964, pp. 731-733) a method was proposed by which the computation time can be reduced at the expense of a longer overall amount of computation, provided a computer with many arithmetic units capable of operating in parallel and of executing rapid data transfers among themselves is available. The parallel network computer envisaged here is ideally suited to the integration method described. Other methods of integrating differential equations which were discredited as numerical procedures because of slow convergence might conceivably gain in importance with the advent of highly parallel computers.

The well-known Picard method, for example, which is commonly used only for the theoretical purpose of proving the existence of a solution to the initial value problem $y' = F(x, y)$, $y(a) = b$. It goes as follows:

$$\text{define } y_o(x) = b, \; y_{n+1}(x) = y_o + \int_a^b F(x, y_n(s))\, ds \quad \text{for } n = 0, 1, \ldots$$

Since numerical integration is an extremely fast operation on a parallel network computer (comparable in time to a single evaluation of the integrand), the slow convergence of the method might well be compensated by the extremely rapid computation, particularly if the solution y is required at only one point.

6.3.4.2 Matrix Calculations

Matrix caluclations arise in such diverse areas as linear programming and other optimization procedures, in some numerical formulations of the solution of partial differential equations and in a good many other areas. The very important problem of Eigenvalue calculations has not received study with regard to numerical techniques for parallel networks although there are some intuitive reasons to believe that the method of successive plane rotation can be applied in parallel. It is altogether clear that power methods are applicable to the parallel approach.

As for the fundamental matrix operations, certainly addition and subtraction pose no new problem.

Matrix multiplication is more complicated. Although the computation of every element of the product matrix AB is independent of the others, taking full advantage of this inherent parallelism would imply storing one row of A and one column of B in every PE memory, which is, for large matrices, undesirable. We can perform matrix multiplication in a manner which, without any duplication of storage or computation, takes advantage of some of the parallelism. Exactly how much depends on details of hardware, such as the relative duration of a multiplication and of transferring one word from central memory to PE memory. If A, B are two k x k matrices and the network contains n x n PE's, where k > n, arrange the first n rows of A and the first n columns of B (for purposes of exposition only) as shown on the next page. In each PE, reserve three registers one each for the current element of A, the current element of B, and the current sum, this latter being initially set to zero.

At one step of the multiplication process, the following actions are taken:

1) Every element of A moves from one PE to its right neighbor, entering at the left (west) boundary of the network in the order indicated by the figure (in the n^{th} row, n-1 zeros will enter before the element a_{n1} enters).

2) Similarly, every element of B moves from one PE to its lower (south) neighbor.

3) The product: current element of A times current element of B is added to the current sum.

$$
\begin{array}{cccccccc}
 & & & & & 0 & 0 \ \cdots & b_{kn} \\
 & & & & & 0 & 0 & \cdot \\
 & & & & & 0 & b_{k2} & \\
 & & & & & b_{k1} & \cdot & \cdot \\
 & & & & & \cdot & \cdot & \\
 & & & & & \cdot & \cdot & b_{2n} \\
 & & & & & \cdot & \cdot & b_{1n} \\
 & & & & & b_{31} & b_{22} & 0 \\
 & & & & & b_{21} & b_{12} & 0 \\
 & & & & & b_{11} & 0 \ \cdots & 0 \\
 & & & & & & \downarrow & \\
 & & & & & & \text{into rows from North} &
\end{array}
$$

$$
\begin{array}{cccccccc}
0 & 0 & 0 & a_{1k} \cdots & a_{13} & a_{12} & a_{11} & \\
0 & 0 & a_{2k} \cdots & a_{23} & a_{22} & a_{21} & 0 & \\
\cdot & & & & & & \cdot & \rightarrow \text{into columns from West} \\
\cdot & & & & & & \cdot & \\
\cdot & & & & & & \cdot & \\
a_{nk} \cdots & a_{n2} & a_{n1} & 0 & 0 & 0 & &
\end{array}
$$

When this step has been repeated k + n - 1 times, the current sum register of the (i - j) PE will contain $(AB)_{ij}$. If k >> n, and if loading 2n PE's with one word each from central memory does not take much longer than a multiplication and addition this method makes very efficient use of the PE network. The desired relation between boundary PE's would be achieved by employing toroidal network geometry.

An alternate approach utilizes the broadcast register of previous designs as follows: In the computation of products A · B, each PE contains a column of B. One row of matrix A at a time is fed through the broadcast register, an element at a time. Each PE executes the same sequence of instructions, namely

$$\sum_{j=1}^{n} a_j b_j$$

thus giving an element of the product matrix. A row of the product matrix is computed simultaneously and remains stored in the network.

In the case of matrices of dimension lower than the dimension of the array the L-buffer can be utilized as a set of broadcast registers; each broadcasting to a row or column in the PE array.

6.3.4.3 Radar Signal Processing

6.3.4.3.1 Tracking

Tracking as accomplished in a track-while-scan system consists of three basic problems: correlation, track initiation, and prediction. Correlation eliminates noise and fixed clutter targets in addition to permitting association of target reports with known tracks and tracks being initiated. New targets fall out of this procedure by virtue of the inability to associate the new target parameters with known data. Track initiation is a special procedure which permits the derivation of initial rates of movements of new targets to allow entry of these targets into refined prediction equations. Prediction utilizes a set of equations which weight current target position parameters, derive rates in these parameters and use past data to extrapolate the position of the target into the near future.

6.3.4.3.1.1 Correlation

The associative feature of previous parallel network designs certainly warrants retention in the proposed system. It is used extensively in the correlation procedure. Data on known targets are maintained current in the processing element array -- one to several targets depending on traffic density -- by the prediction function. New data filters through the central control and is sequentially broadcast to the array through the broadcast registers. Within the PE's the new data are compared to the current data and mode change made to identify known targets. More than one target may respond in which case more refined comparisons may be made on higher order derivatives of position if available. The data which have not matched known targets may be treated in two ways. They may be distributed among the processing elements thus forming new track files or may be maintained within the central control for comparison with data gathered during the next cycle of radar operation (next scan).

Known targets may consist of dynamic or static reflectors. If they are static they are most probably ground clutter or reflections occurring from refractive anomalies within the atmosphere that change slowly with time. Clutter may be stored within the PE array in special files which are compared with reports which do not associate with known targets. Additionally slight clutter motion may be accommodated in almost the same manner as tracks. Correlation procedures for clutter are more difficult to implement since the reflectors are most likely distributed over a large area or volume.

It is important to note that it is not simply the associative property of the network which is employed in correlation. It is the ability to associate dynamically, that is, to associate new data with a constantly changing data base. In other words the ability of PEM (when considered as an associative memory) to do logic and arithmetic.

6.3.4.3.1.2 Track Initiation

Track initiation may be performed in the array or in central control depending upon the rate of arrival of new targets and the number of track files being maintained. Position parameters of targets which do not correlate with those of known targets are assigned PEM or central memory

accordingly. Wide correlation limits are established on these targets since their velocity vectors have not been established. Correlation takes place with reports received during the next scan assuming some maximum velocity for the targets. If correlation is not successful the reports are assumed to be noise. If correlation is successful initial velocity vectors for these targets are calculated.

A benefit of the capacity of the system both in speed and in storage is the ability to accept a much higher false alarm rate from the radar. This implies the ability to lower radar detection system threshold and thereby increase the sensitivity of the radar and thus the probability of detection.

6.3.4.3.1.3 Prediction

Track files are maintained within the processing elements and consist of the measured and predicted position parameters of the targets as well as appropriate smoothing constants for the prediction equations. Files may be structured into layers within the array to provide flexibility in the degree of refinement of the predictions. That is, either different equations may be used for each layer or different data rates may be required for targets of different classes. (For example, such filing procedures might be used for a mixed threat of aircraft and long range hypersonic missiles.) The equations of each layer are solved simultaneously and the layers treated successively at the required rates.

The problem of track merging and splitting can be eased by attempting associations of positions of each track being maintained with all tracks in the system. Where associations exist within certain limits, special procedures must be initiated to preclude loss of targets. An obvious solution is to raise the data rate or refine the prediction equations to maintain the individuality of tracks. Simply moving the track files or problem targets to a layer of higher data rate or greater precision may suffice entirely.

6.3.4.3.2 Matched Filters and Pulse Compression

The speed of the proposed parallel array permits the performance of pulse compression and matched filtering in system real time. Advantages of digital pulse compression using a general purpose array are the multi-functional aspect of the filtering system and the flexibility in implementing filters of differing qualities.

Assuming the signals to consists of n discrete lines spaced by Δf the resolution which may be achieved by such a signal is $1/(n-1)\ \Delta f$. The usual method for compression is to provide analog multiport summing devices at IF to accommodate a particular set of ranges and doppler frequencies. If the IF signals are digitized, stored in PEM and a digital correlation for each range-doppler cell performed then pulse compression may also be accomplished. Clearly, for many systems one iteration of the correlation function could form a complete range-doppler map. Discrimination in AICBM systems may be aided by the flexibility of this approach.

6.3.4.3.3 Radar Control

A parallel array can certainly be employed to calculate phase shifter settings in real time for large phased array radars. A mapping of the elements of the array onto the PE array with simultaneous calculation to establish the phase settings yields a very short solution time in this problem. The ability to output in parallel the settings to the phase control elements of the array is also significant in this application.

6.3.4.4 Seismometer Signal Processing

A problem was posed by ARPA in April, 1965, dealing with the reconstruction of beams from signals gathered by a phased array of 500 seismometers. A brief study was conducted at Westinghouse Electric Corporation with the results reported to the Information Processing Office of ARPA.

6.3.4.5 Program Optimization

The problem of machine code optimization is usually regarded as a problem of compilation. This usually implies that the operations and modifications performed on the program to be optimized are of a highly local nature, i.e., only those improvements can be done on any one statement which depend only on a knowledge of a few neighboring statements. Among the effects which can be achieved despite this limitation are:

1) reducing the number of load, store and register transfer instructions,

2) elimination of common subexpressions within one statement or a single block of statements,

3) removal of subexpressions and statements with a loop (of a restricted and easily recognizable type, such as a DO loop (in FORTRAN)) if their values are independent of the loop index,

4) reordering of arithmetic expressions to enable the evaluation at compile-time of as many subexpressions as possible (cf. Gear, C. W., "Optimization of the Address-Field Compilation in the ILLIAC II Assembler", Computer Journal, Vol. 6, No. 4, January, 1964, pp. 332-335).

Recently a new technique for machine code optimization has been proposed (Nievergelt, J., "On the Automatic Simplification of Computer Programs", Comm. ACM, Vol. 8, No. 6, June, 1965, pp. 366-370) which works on a strictly global basis, i.e., at any one time operates based on information from the whole program, and hence can do a great deal more than what is listed above. The optimizations performed in this scheme are classified into jump, node, and chain simplifications, depending on whether they operate on the graph describing the flow of control through the program, in the vicinity of a branch point, or on a linear sequence of instructions between two branch points. Most of the optimizations require searching through extensive tables without any logic priority (i.e., one may arrange them as a parallel search).

A parallel network computer would seem to be well-suited for this kind of optimization, which might take a prohibitive amount of time on a conventional computer.

6.3.4.6 Adaptive System Simulation

A great variety of existing and contemplating adaptive system models have been studied. Generally they have been constructed to reflect various characteristics or functional properties of biological systems and it is the processing concept rather than the hardware mechanization that is the significant object of study. From the point of view of computer organization it is pertinent to evaluate the effectiveness of alternate hardware configurations in executing these processing algorithms as well as evaluating the effectiveness of the algorithms.

A typical adaptive network of Perceptron type consists of sensory (S) units which are binary, association (A) units which produce an output if a sufficient number of S units that supply it are activated and result (R) units which compute weighted sums of the outputs of the A units. Thus an output vector is

$$R_m = \sum_{i=1}^{n} \lambda_{mi} \cdot a_i$$

where the vector a is a characteristic of the input pattern which in general is subjected to a coordinate transformation and the λ's are the weights. A parallel network machine can perform this operation quite efficiently with each PE computing a specific R based on its own stored values λ_{ij}. The values are common inputs to all PE so that they can be broadcast element by element to the network.

The advantages of using the parallel network are:

1) it is much cheaper to store variables such as the λ matrix in core memory than in active hardware; therefore many more such values can be stored

2) linear and nonlinear transformations can be applied to the input pattern by the same hardware unit

3) the system is programmable so that far more flexibility is available; the computational power of the proposed network and its efficiency in this application make it possible to realize far larger networks then are practical by direct hardware implementation

4) multilevel and variable structure nets can be programmed

5) syntactical structures such as those described by Narasimhan (Narasimhan, R., "Labelling Schemata and Syntactic Descriptions of Pictures", Information and Control, Vol. 7, 1964) can be used for hierarchy of decisions. Similar processes have been developed for associative processors by Fuller (Fuller, R. H., "Algorithms for Content-Addressable Memories", Proc. Pacific Computer Conference, 1963).

7. ILLIAC II SERVICE, USE, AND PROGRAM DEVELOPMENT

(This work is supported in part by Contract No. AT(11-1)-1469 of the Atomic Energy Commission and in part by the University of Illinois.)

7.1 ILLIAC II Program Development

7.1.1 Progress

This quarter has seen refinements and additions to the existing nontime-sharing and time-sharing systems. A package which handles input-output to the disk files and another which communicates with the teletype have been added to the in-core monitor. This has resulted in a five-block monitor for the time-sharing system which was put into operation on September 15, 1965. The file update program was enlarged and modified to run in the interrupt allowed mode. This program, now called BOOTS, is run from the teletype in a time-shared manner and allows users to modify programs which exist on their file tapes without going through new code checks.

The ILLIAC II Library is being organized and the subroutines are being updated to conform with new system requirements. Additions to the Library this quarter consisted mainly of CalComp routines which made plotter output easier and more flexible. New options have been included in the Special Register 34 dump programs.

The System Tape Update program was modified to run in the interrupt allowed mode and plans are being made for further changes which will allow System Tape Updates to be run as a normal batch processing job, i.e., put on the input tape with other user jobs. Corrections continue on FØRTRAN and work is progressing on development of the Macro Prepass.

During Activity Day at the University, there was a demonstration of SØC on the remote console.

7.1.2 System Program Development

Modifications to the system concentrated mainly on making it more efficient, reliable, and automatic. The Special Register 34 dumps program was reworked in order to make it run in the interrupt allowed mode and new green

switch options were added. In certain cases, when an error occurs, a message is printed out giving clues to the difficulty. A tape compare routine was added and is most helpful in ensuring a valid tape copy. The new feature of a mnemonic core dump came in very handy in determining exactly what was on our Library Tape.

There is now a drum-tape bootstrap board. The bootstrap boards and bootstrap programs were modified to use only a long (or full) first block. This standardized the "looks" of the system and engineering test tapes. This also enables the System Update program to handle the bootstrap program as any other on the system tape. The Systems Tape Update program was itself modified to run in the interrupt allowed mode so that except for a special Special Register 34 setting, all update jobs are run under control of the batch processor as a regular code check.

SYSAUX for disks (an input-output package) is now a part of the Off-Line Monitor and available for user and system programs. It was reprogrammed to handle a modified shorter CALL sequence. Error recovery portions were added and presently reside in core; new error messages for the disk were supplied for use by an enlarged SYSERR routine. Further code-checking of additional options remains to be done and other modifications will be made at a later date. In the meantime, it is planned that certain existing programs will be modified to run from the disk files.

At present in the time-share system all tape drives are used by the system. The batch work submitted from cards and the time-share work coming in from the remote consoles need separate input, output, and scratch tapes. The drum is used for core swaps. At the end of an output tape, a plotter tape is automatically made and messages are typed to the operator telling which users have plotter output. It is planned that part of this time-share system will be put on the disk file in order to free some tapes for the user, to speed up system operation, and to provide more scratch space.

Pertinent publications were:

Title	Source	Date
Special Register 34 Dumps Program	Memorandum	July 12, 1965
Disk SYSAUX	Prog. Memo. #6 Change 1	September 14, 1965

7.1.3 FØRTRAN, The ILLIAC II Compiler

The FØRTRAN compiler was updated in August so that the present system tape has the following corrections and additions:

1) Hollerith fields may now be used in arithmetic assignment statements and call statements (with an H field width of not more than one ILLIAC word or eight characters), as well as the previously allowed use in format statements.

2) Sense light 0 now works.

3) Constants in the source deck where the absolute value of N + E (i.e., the number of digits after the decimal point plus the exponent given) is greater than 15 are now calculated correctly.

4) Temporary storage for arithmetic functions has now been corrected to avoid multiple use.

5) Call parameters in the call statement has been extended to give pointers to a particular vector in an array (i.e., variable indexes may be used in arrays to transfer one or more elements from a subroutine or function).

6) New check and error messages have been added.

It might be noted that the CalComp routines are FØRTRAN compatible and can be called as subroutines in the normal manner.

7.1.4 NICAP MACRO PREPASS

Final preparations are being made for including the NICAP PREPASS on the System Tape. Implementation of the basic vocabulary is in the final stages of code-check.

7.1.5 LIBRARY, ILLIAC II

The main project of the ILLIAC II Library this quarter was organization of existing routines. Source decks and binary decks were collected, labeled, and reproduced. There now exist two source decks and at least three binary decks for each subroutine on the Library Tape. Compilation has been completed of four books each of which consists of a Library Tape table of contents followed by a listing for each of the subroutines on the Library Tape. A new procedure for checking out updated Library Tapes has been instituted and is much more certain to catch any errors which might exist. A log is now kept of all Library Tape changes and manipulation. Furthermore, a fixed format for subroutine write-ups was selected. In toto, an attempt is being made to determine just what is included in the ILLIAC II Library and to relieve the hitherto chaotic state.

The graphing routine for the off-line printer is now working and will be put on Library Tape. The graph may have unlimited length in the independent variable direction (since this is the direction of paper movement) and is thus not necessarily restricted by core size. One to seven separate curves may be plotted simultaneously on one graph. The number of dependent and independent grid lines may be specified as well as the spacing between them. One entry to the subroutine will print a complete graph if the coordinates of all the points are given. Thus in most cases, the user will find the variety offered by this subroutine more than sufficient.

Many new subroutines for the CalComp were programmed and already existing ones were corrected and modified. They all may be called from ILLIAC II FØRTRAN and/or NICAP. CCP1PL (PLØT) is the most basic CalComp routine and puts out the pen movements for all of the other subroutines. Other entries to the same routine, each of which has its special function, are CCP1FR (FACTØR), CCP1ØS (OFFSET), and CCP1PP (WHERE). CCP2SY (SYMBØL) is a CalComp routine which draws N alphanumeric characters on the plotter with a specified height and at a specified angle with respect to the x-axis. It recently has been modified to allow CCP3NR to plot floating point numbers. Both of the above mentioned routines are on the Library Tape and provisional write-ups have been distributed. Formal documents for the ILLIAC II Manual have been written up for two other routines which exist

on the Tape--CCP4SC (SCALE) and CCP6LN (LINE). The former scales an array without destroying the array while the latter connects the points of an X and Y array with straight lines. Thus if the x and y increments are small, a curve may be generated. Other CalComp routines which are on the Library Tape but have not been documented are:

PLSCI, DXDY --two routines used together. They will scale an array (and make it entirely positive during the scaling process), changing the values in the array so that they may be plotted in a DØ loop with CCP1PL.

CCP7RT(RECT)--will draw a rectangle of a given size at any angle with respect to the x-axis.

CP1OGD(GRID)--will draw x and y grid lines of any size and spacing.

XYZPLT--produces a 3-dimensional plot rotated properly in relation to the observer's position in space.

Four further CalComp routines have been programmed. They are:

CCP3NR(NUMBER)--which will plot floating point numbers.

CCP5AX (AXIS)--which draws an axis at a given angle with labels, numbers, and a scale factor if necessary.

CCP8DL (DASHLN)--which will connect two points with a dashed or undashed line possibly using the values obtained from CCP1ØS.

CCP9DN (DIMENS)--which draws dimension arrows and is particularly useful for drafting projects.

Other routines being planned or written include one to produce an ellipse or circle; another to plot the user's function (given in a separate subroutine), and a third which is a modification of the PRINT routine and will allow the plotting of characters much like any PRINT call.

Apart from the CalComp routines, four other subroutines have been put on the Library Tape but do not yet have write-ups. They are:

PTIME--, PTBCDM--, PTBCDS-- all of which deal with paper tape manipulation and are part of the package called TØPS.

BPLT--which is a Bode Plot Evaluation.

Present efforts are directed principally toward two areas. The first is that of updating subroutines now on the Library Tape to make them compatible with the present system, and, in some cases, available to FØRTRAN as well as NICAP users. The second area is that of documentation of new subroutines and of those now on the Library Tape for which poor write-ups exist.

A memorandum entitled "Changing the Library Tape and Format for Subroutine Write-Ups" was distributed.

7.1.6 CalComp, Digital Incremental Plotter

ILLIAC II processes jobs with plotter output at every code-check, thus giving short turnaround time. The only special requirement is that a user must insert after his I.D. card a $$ card marked "PLØTTER ØUTPUT." This warns the operator that there is plotter information on the output tape and plotter results to be returned. The time-sharing system automatically collects all plotter output off the output tape and generates a tape to be hung on the CalComp. Available subroutines make the CalComp a most useful piece of equipment.

7.1.7 Program Plans

Plans for the future include expansion of the existing compiler and assembler, the addition of MACRO's, an increase in the scope of the ILLIAC II Library, and further programming of CalComp routines. The main concern, however, is the development of a large scale time-sharing system for ILLIAC II.

7.2 Engineering Test Programming

7.2.1 Channel Assembly Program

CAP (Channel Assembly Program) is a simple console-oriented assembly program which accepts a set of mnemonic instructions and builds an appropriate machine code. It is expected to be particularly useful in debugging new interplay channels and in diagnosing obscure channel malfunctions. The program is now in usable, but incomplete form. Mnemonic instructions may be easily changed, and it is expected that the skeleton program will find additional applications in other areas.

7.2.2 CAVITIES

CAVITIES is a bootstrap program designed to load engineering tests into ILLIAC II for convenient use during diagnosis of machine errors. It contains facilities for operating from drum or magnetic tape and it has its own routines for updating its test library. The reference for this work is:

"CAVITIES: (Condensed Automatic Variably Indexed Type Integrated Engineering System) A General Purpose Bootstrap Program," by Donald Bennett, DCS File No. 682, June 29, 1965.

7.3 ILLIAC II Drum Memory

Four file numbers describing aspects of the magnetic drum memory were written, all by H. C. Brearley.

"Head Adjustments on the Flying Head Drums," DCS File No. 670, July 8, 1965.

"A Thermistor Temperature Indicator and Alarm," DCS File No. 672, June 28, 1965.

"Head Retraction of the Flying Head Drum," DCS File No. 676, July 20, 1965.

"ILLIAC II Magnetic Drum Memory Operation and Maintenance Manual," DCS File No. 673, June 15, 1965.

7.4 CalComp Hardware Aspects

CalComp usage during the summer has shown some need for mechanical changes as well as a need for a user's group to aid in effective use of the plotter.

The mechanical problems resolved themselves to (1) a bad hub on the tape drive (2) a deficiency in the ink pen-paper combination. These have been taken care of. As far as a user's group is concerned there are plans to organize such a group in October.

TABLE I. ILLIAC II LOG SUMMARY--JULY, AUGUST, SEPTEMBER, 1965

ILLIAC II Use

	July	August	September	Totals
ENGINEERING				
General Engineering	217:55	231:09	215:25	664:29
Drum Engineering	2:00			2:00
Disk Engineering	82:31	58:02	20:05	160:38
Core Engineering		3:58		3:58
1050 Engineering		:05		:05
Sub Totals	302:26	293:14	235:30	831:10
ENGINEERING TESTS				
AEC	174:56	146:48	160:57	482:41
KETPG	2:54			2:54
Sub Totals	177:50	146:48	160:57	485:35
PRODUCTIVE USE OF ILLIAC				
Code Checks and Production	116:13	177:42	130:29	424:24
Math 195	2:19	:46	:59	4:04
Other	122:44	102:45	159:15	384:16
Demonstrations	4:55	6:52	5:26	17:13
Sub Totals	246:11	287:37	296:09	829:57

TABLE I. ILLIAC II LOG SUMMARY--JULY, AUGUST, SEPTEMBER, 1965 (Cont'd)

	July	August	September	Totals
MISCELLANEOUS				
Down	2:44	3:00	:15	5:59
Idle	14:49	13:21	27:09	55:19
Sub Totals	17:33	16:21	27:24	61:18

TOTAL TIME IN OPERATION FOR QUARTER 2208:00 Hours.

PERCENTAGE ANALYSIS OF TIME FOR QUARTER

Percentage of Time Used for Engineering	37.6
Percentage of Time Used for Engineering Tests	22.0
Percentage of Time Used for Production	37.6
Percentage of Time Used for Miscellaneous	2.8
Total	100.0

TABLE II. IBM 1401 LOG SUMMARY--JULY, AUGUST, SEPTEMBER, 1965

IBM 1401 Use	July	August	September	Totals
ENGINEERING				
IBM Engineering	30:32	6:58	6:36	44:06
ILLIAC Engineering	7:00	28:00	38:07	73:07
Disk Engineering	20:45	15:11	9:15	45:11
Sub Totals	58:17	50:09	53:58	162:24
ENGINEERING TESTS				
Core Worst	1:30	180:51	325:41	508:02
AEC	:24	11:22	:44	12:30
BTC	1:30	2:17	:14	4:01
KETPG	2:27			2:27
Sub Totals	5:51	194:30	326:39	527:00
PRODUCTIVE USE OF 1401				
ILLIAC Prep	159:55	221:03	157:41	538:39
Off Line	50:26	58:07	30:44	139:17
Group Use	109:35	77:50	80:40	268:05
Sub Totals	319:56	357:00	269:05	946:01

TABLE II. IBM 1401 LOG SUMMARY--JULY, AUGUST, SEPTEMBER, 1965 (Cont'd)

	July	August	September	Totals
MISCELLANEOUS				
Idle	358:56	142:21	70:18	571:35
Wasted	1:00			1:00
Sub Totals	359:56	142:21	70:18	572:35

TOTAL TIME IN OPERATION FOR QUARTER 2208:00 Hours.

PERCENTAGE ANALYSIS OF TIME FOR QUARTER

Percentage of Time Used for Engineering	27.3
Percentage of Time Used for Engineering Tests	23.9
Percentage of Time Used for Production	42.8
Percentage of Time Idle, Wasted	26.0
Total	100.0

TABLE III. ILLIAC II ENGINEERING LOG SUMMARY--

JULY, AUGUST, SEPTEMBER, 1965

ERROR ANALYSIS ILLIAC II

	July	August	September	Total
Air Conditioner	1	0	0	1
Advanced Control	3	1	2	6
Core 1	4	**11	2	17
Core 0	2	3	4	9
Console	1	0	0	1
Flow Gating	4	0	1	5
Power Supplies (Main Frame)	5	8	7	20
Power Supplies (I/O)	6	3	1	10
Selectric (Typewriters)	1	0	1	2
SRDP	2	5	2	9
1401 A	0	4	0	4
1414 A	0	2	*5	7
1414 B	0	3	1	4
1050	0	1	0	1
Drum	0	2	0	2
Special Registers	0	0	2	2
Human Error	0	0	2	2
Unknown	0	0	2	2
Muffin Fans	0	0	1	1
1301 A	0	0	1	1
Tape Units	2	9	3	14
Delayed Control	3	1	1	5
RTDC	0	3	0	3
	34	56	38	128

* Indicates trouble with channel which continued for several days.

** A new chassis was placed into service in Core 1 which caused intermittent trouble.

TABLE III. ILLIAC II ENGINEERING LOG SUMMARY--

JULY, AUGUST, SEPTEMBER, 1965 (Cont'd)

EQUIPMENT REQUIRING SERVICING

IBM On-Line Equipment Requiring Services of C. E.

	July	August	September	Total
1401	2	1	0	3
1403	1	0	0	1
Selectric (Typewriters)	2	0	0	2
Tape Drives	3	3	22	28
Synchronizer (1414C)	0	0	1	1
7631B	0	0	1	1
1301B	0	0	1	1
	8	4	25	37

IBM Off-Line Equipment Requiring Services of C. E.

026 (Punches)	1	1	5	7
514 (Reproducer)	1	0	1	2
Interpreter Key Punch	1	0	0	1
1052	2	0	1	3
1056	1	0	0	1
1051	0	0	1	1
	6	1	8	15

Miscellaneous Off-Line Equipment Requiring Servicing

Plotter Tape Unit	1	1	0	2
Plotter	0	0	1	1
Tape Printer	1	0	0	1
Tally	1	1	0	2
TTY	0	0	0	0
Data Set	0	1	1	2
	3	3	2	8

TABLE III. ILLIAC II ENGINEERING LOG SUMMARY--

JULY, AUGUST, SEPTEMBER, 1965 (Cont'd)

SCHEDULED DIAGNOSTIC ENGINEERING

Maintenance:

Checking transistors	10	hours
Marginal DC voltage tests	28	hours
Upgrading Core 1 for reliability	18	hours
Updating of I/O cabinet (preparing for future covers)	15	hours
Printed Circuit Boards (replating contacts, updating numbering scheme, etc.)	8	hours
Component replacement tests (trying new transistors, semiconductors, etc., to replace obsolete items)	5	hours
Core 0 modification	10	hours

Component Failures:

Transistors in main frame (main frame, Core 1, interplay, drum and power supplies)	
Main Machine	40,121
Power supplies	3,592
Total	43,713
Transistors replaced	28
Semiconductors in main machine (diodes, zeners, etc.)	
Total	81,946
Semiconductors replaced	9
Number of printed circuit cards in I/O equipment	
Total	1,655
Circuit Cards replaced	74

TABLE III. ILLIAC II ENGINEERING LOG SUMMARY--

JULY, AUGUST, SEPTEMBER, 1965 (Cont'd)

Comments

A source has been found to obtain N250 transistors (REF: Quarterly Technical Progress Report for October--December, 1964).

GF45011 replacement-checked 2N1495 transistor that had been placed into chassis A #3 and found they would not replace the GF45011. The 2N1495 fail the following tests: α_2, V_{EB1}, V_{EB2}.

Section 7 of the Quarterly Progress Report has been written by J. Aaron, D. Bennett, H. C. Brearley, E. Brower, L. Byers, C. Carter, D. Conroy, R. Fisher, C. W. Gear, E. Hassler, L. Holland, W. Huffman, G. Huszar, D. Juran, J. Kelly, T. Kerkering, R. Kingsley, S. Krabbe, H. Lopeman, R. Lyon, R. Miller, P. Neuhaus, F. Richardson, F. Rohatsch, J. Semler, T. Slivinski, and J. Watkins.

8. IBM SERVICE, USE, AND PROGRAM DEVELOPMENT

(Supported in part by the National Science Foundation under Grant No. NSF-GP-700.)

8.1 New Routines

C3-UOI-FAC2-27-SR

Floating point factorial. This routine provides the floating point value of I!, where I is a fixed point FØRTRAN or SCATRE integer such that $0 \leq I \leq 33$. A simple table look-up procedure is used.

August 2, 1965

B4-UOI-CUR3-38-SR

Floating point cube root. This program computes the cube root of any normalized floating point number. The error in the fractional part of the result is less than 2^{-27}.

Programmed by David Hutchinson
Revised by David Ring
August 13, 1965

B4-UOI-CUR4-40-SR

Double Precision Floating Point Cube Root. This routine computes the real cube root of any normalized double precision floating point number.

Programmed by David Hutchinson
Revised by David Ring
August 13, 1965

D2-UOI-RKY4-46-SR

Floating Point Runge-Kutta. This program solves a set of N simultaneous, first order, ordinary differential equations in floating point arithmetic. This routine should be used rather than RKY3 on a 7094 since this routine utilizes the 7094 double precision orders and therefore is much faster than RKY3.

This routine was originally programmed for the IBM 704 as MURKY3 by Elizabeth Z. Chapman, April 3, 1957, Midwestern Universities Research Association, Madison, Wisconsin.

Modified by Eugene Chang
August 2, 1965

D2-UOI-NØR1-56-SR

Floating point Nordsieck-Method Integrator. The method of integration is presented in detail in a paper by A. T. Nordsieck: "On Numerical Integration of Ordinary Differential Equations", Mathematics of Computation, Vol. 16, No. 77, January, 1962, pp. 22-49. The method used here is that outlined and presented in the article, with appropriate modifications for floating-point. The derivatives f_i are evaluated by an auxiliary subroutine which must be provided by the user.

Programmed by Ida Hassler
August 19, 1964
Revised July 12, 1965

CO-UOI-UTR1-84-SR

Given x = f(x), this subroutine finds a root of this equation within an error specified by the user. The method of successive substitutions is used with a recurrence relation of the form

$$X_{n+1} = [AX_n - f(X_n)]/(A-1)$$

where

$$A = \frac{f(X_n) - f(X_{n-1})}{X_n - X_{n-1}}$$

The value for x is iterated using the method of false position until a convergence test specified by the user is satisfied. The user must also supply the initial approximation x_0. The formula used to start the iterations is simply $x_1 = f(x_0)$.

The accuracy of the method depends upon the criteria for convergence tests, specified by the user.

July 12, 1965

A1-UOI-QPA1-87-SR Addition and subtraction subroutine for quadruple precision arithmetic. This subroutine is one of a set of six subroutines (QPA1, QPA2, QPA3, QPA4, QPA5, and QPA6) which perform multiple-precision floating point arithmetic with an accuracy of approximately 31 decimal digits, or four times the accuracy of normal floating-point arithmetic. To attain this accuracy, four words of 7094 core storage are required to represent each quadruple precision number.

Adapted from A1 BC SUPA by
C. C. Fretwell
John R. Ehrman
July 30, 1965

A1-UOI-QPA2-88-SR Multiplication of two quadruple precision numbers, or of a single precision number and a quadruple precision number, to give a quadruple precision product.

Programmed by John Ehrman
July 27, 1965

A1-UOI-QPA3-89-SR Division routine for quadruple precision arithmetic.

Adapted from A1 BC SUPA by
C. C. Fretwell
John R. Ehrman
July 30, 1965

A1-UOI-QPA4-90-SR Conversion of quadruple precision numbers to and from single and double precision forms.

Programmed by John Ehrman
July 30, 1965

A1-UOI-QPA5-91-SR Square root routine for quadruple precision numbers.

Programmed by John Ehrman
July 30, 1965

A1-U0I-QPA6-92-SR

Convert quadruple precision numbers to and from strings of BCD characters.

Programmed by
C. C. Fretwell
John R. Ehrman
July 30, 1965

B1-U0I-ATN1-96-SR

Floating point single-valued arctangent. This subroutine computes the single value of arctan (Y/X) in the range from 0 to 2π for floating point arguments X and Y. In a test of over 20,000 arguments the largest error found was less than 3 units in the sixth decimal digit. ATN1 originated in the Michigan Executive System.

Modified by Fran Benard
August 13, 1965

B1-U0I-ATAN-97-SR

Floating point principle-valued arctangent. This program calculates the principal value of arctan (X) for floating point arguments X. Test results yielded a maximum error of 1 unit in the eighth decimal digit. This subroutine originated in the Michigan Executive System.

Modified by Fran Benard
August 13, 1965

(Supported in part by the National Science Foundation under Grant No. NSF-GP-700.)

9.1 Research Problem Specifications

During the third quarter of 1965, 128 problem specifications were submitted to the Department for computation. The following brief descriptions of these problems have been prepared for inclusion in this report by those submitting them. T indicates a calculation associated with a thesis.

1539-57001 State Water Survey. Nonparametric Statistical Tests. Let A = number of wells with specific capacity above combined median specific capacity (with respect to sand and gravel), let B = same as A but with respect to till instead of sand and gravel, let C = same as A but below the median, and let D = same as B but below the median.

The technique used will be: 1. Tabulate specific capacities for all wells in both categories in order of magnitude and determine the median of the combined well categories. 2. Prepare the table above by splitting specific capacities in each well category at the median specific capacity determined in Step 1. 3. Determine probability using either Fisher's exact probability test or X^2 test according to certain rules using the following equations:

Fisher's

$$P = \frac{(A+B)!\ (A+C)!\ (B+D)!\ (C+D!}{N!\ A!\ B!\ C!\ D!}$$

Chi-Square

$$X^2 = \frac{N(AD - BC - N/2)^2}{(A+B)\ (C+D)\ (A+C)\ (B+D)}$$

Routines developed by the Illinois State Water Survey will be used. (Robert Sinclair)

1540-57002 T Marketing. An Investigation of the Advertising Practices of the dealer Subscribers to Office Appliances. This study is an investigation of the advertising practices of the independent office products dealers (retailers) who subscribe to Office Appliances, a trade magazine in the office equipment field. The study analyzes their advertising budgets, the media they use and their use of cooperative advertising.

The computer will be used for frequency counts, cross tabulations and statistical analyses. (Philip L. Hupfer)

1541-57003 T Chemistry and Chemical Engineering. Complex Decay Curve Analysis. The computer is to be used to decompose complex radioactive decay curves into their component parts. This is to be done using a standard least-squares analysis technique to obtain the best fits for the component half-lives and their zero-time intercepts. (John Hummel)

1542-57004 Electrical Engineering. Heat Conduction in Protonosphere. A calculation of the rate of heat conduction along the geomagnetic field lines in the protonosphere involves solution of the equation

$$\frac{\partial}{\partial x}\left(p(x)\ \frac{\partial u}{\partial x}\right) = f(x)\, u^{m}\ \frac{\partial u}{\partial t}$$

with initial conditions $u(u,o)=1$ and boundary conditions

$$u(uo,t) = (t_1/t_o)^{7/2},\quad \left.\frac{\partial u}{\partial x}\right|_{x=o} = 0.$$

The method used is based on the modified difference formula derived in "Approximate Solutions of Parabolic Equations", in J. Soc. Indust. App. Math. 7 2, 1959. (Jec Gliddon)

1543-57005 Library Science. Textbook Price Index. It is desired to make a compilation of cost data for college textbooks to establish an index of prices for 1959-61-63. This final listing follows a previous compilation of cost data for elementary and secondary school textbooks, and is arranged in subject categories, form of materials, and by publisher totals. (Goldstein)

1544-57006 Physics. Color - Center Data Reduction. This research project is a study of the relationship of "F" and "M" center concentrations produced by X-rays at liquid helium temperatures. The computer provides an efficient method to obtain least squares fits to the spectra generated in the experiment. This provides a method to accurately locate band maxima and separate overlapping absorption bands. (W. D. Compton)

1545-57007 Physical Education for Men. Attitude Poll of PEM Basic Instruction Students at the University of Illinois. The purpose of this study is to determine the attitude of University of Illinois men enrolled in the PEM Basic Instruction Program toward the University Physical Education requirement.

An attitude questionnaire was completed by male students enrolled in the PEM Basic Instruction Program during the last week of the Spring, 1965 semester.

The questionnaire was one page in length and contained sixteen questions. Items "a" through "e" on the questionnaire were not questions regarding student attitude, but rather, classification information from which the questionnaires could be sorted into groups. Respondents were identified as to college, curriculum, physical education course and section, but no identification of individual respondents was possible. Five questions were answered by circling "yes", "not sure", or "no". Five questions were answered by circling between 0 and 8 semester hours or hours per week. For questions 11 through 15, space was provided for rating physical education courses. Nowhere in the questionnaire was the student asked to present a written statement expressing his attitude. The questionnaires were administered only once, and there were no follow-ups attempted.

Information from each questionnaire is to be transferred to IBM cards for greater ease in handling the data. These cards are to be used in determining counts for men on each of the questions. All subsequent machine sortings are to be done by the researcher.

Cards are to be sorted according to student college-level physical education experience based on previous semesters of physical education taken at the University of Illinois or elsewhere.

Cards are to be sorted into five groups, namely:

I. Students with no previous university or college physical education experience.

II. Students with all previous physical education experience at the University of Illinois.

III. Students with some previous physical education elsewhere.

IV. Students with <u>all</u> previous physical education elsewhere.

V. "Others" who failed to answer items a and/or b.

Cards also are to be sorted according to the colleges in which the students are enrolled, and according to the instructors the students had for their present physical education course, whether they are full-time or part-time assistants. Following each sorting by categories, counts are to be made of responses to all questions. The Chi-Square test, as outlined by Edwards, is to be used to determine whether significant differences exist in response between the various groups.

Inter-correlations are to be calculated between questions 1 through 10 by the University of Illinois electronic computer. Correlation matrices are to be made. Means and standard deviations on questions 1 through 10 are also to be calculated by the computer. (Arnold W. Flath)

1546-57008 Nuclear Engineering. Computer-Library. A few codes related to reactor physics, reactor heat transfer, reactor kinetics, shielding, fluid flow, etc. are to be tested. These codes will later be used for teaching purposes in the nuclear engineering program. (K. Y. Cheung)

1547-57009 Forestry. MeIntire-Stennis Growth, Development, Forest Trees, 55-303. Information about the woody vegetation of Trelease woods, Champaign County, Illinois, including stand composition and ecological trends, will be derived from data which includes tree species, diameter in inches, and condition class. This data, which has been recorded in 96 50-meter square sample blocks, will be tabulated in the form of frequency tables for interpretation. (W. R. Boggess)

1548-57011 Psychology. Piaget-Guttman Child Development Scale. The purpose of this problem is to develop an ordinal scale of psychological development of infants between birth and two years of age. The computer will be used for four major types of data analysis, corresponding to the following steps: (1) frequency distributions will be computed for a number of test items, taken by two independent observers each at two different times; (2) correlation coefficients for all the above items will be computed; (3) the data will be recoded and pooled so as to eliminate items with low reliability correlations; (4) the pooled data will then be analyzed to see if it forms a perfect Guttman scale. (J.McV. Hunt)

1549-57012 University High School. UICSM Instructional Research. The UICSM Instructional Research Apparatus is a multiple-purpose electromechanical apparatus. One student at a time is run, under self-instruction conditions. Response and time data are collected on 8-channel punched paper tape. Equipment outside the Department of Computer Science is used to transcribe the data from paper tape to standard computer magnetic tape. Each 8-bit code from the paper tape is transcribed to a 3-digit word on the magnetic tape. The 7094 will be used to reduce this raw data to a short record of events for each experimental session which will be both printed and stored on tape for further processing. The further processing will consist for the most part of simple descriptive statistics such as percentages, means, etc.

Most instructional research measures results in terms of amount of success attained in fixed time. The primary purpose of the present research is to determine to what extent and under what conditions time-to-mastery can be used as the principal dependent variable in instructional research. That is to say, rather than hold time constant and allow achievement to vary, the minimum criterion of achievement will be fixed and time-to-criterion will be allowed to vary. (Gilpin)

1550-57013 Department of Computer Science. Computer Music. Studies in musical composition by computer for conventional instruments, for the CSX-1 computer and for the digital to analog converter are planned. In the earlier studies, stochastic methods will be employed (in the manner of Xenrkis and Thiller); later some of the Schillinger techniques will be programmed. (John Myhill)

1551-57015 T Psychology. Discovery of Psychological States of Depression by R Technique Factor Analysis. The purpose of this research is to discover the natural day-to-day change of psychological variables in a single subject. The specific concern is the clusters of variables formed by symptoms of depression as they change from day-to-day. Eighty symptoms of depression were measured by questionnaires, rating scales and objective psychological tests on 78 occasions for a single person. From the

correlation matrix 14 factors were extracted by the Illiac factor analytic routine KSL 1.21, and rotated by Oblimax, and visually, using the "Psycho" program. The remaining 40 variables were extended to the resulting structure of 14 factors, using the Dwyer Method of extension. The rotation is as yet incomplete, and the computer is therefore now needed to obtain further rotations via a maxplane routine solution. (L. F. Vanegeren)

1552-57016 T Electrical Engineering. Power Computations on Periodic Structures. The problem is to calculate the power radiated in the transverse direction on several periodic structures. Using the known electromagnetic field equations and propagation constants in conjunction with the computer, the complex Poynting vector will be calculated as a function of axial distance along the periodic structure. It is hoped that these calculations will provide greater insight into the mechanism of radiation from periodic structures. (Don Wilton)

1553-57017 Department of Computer Science. Library Information Retrieval. The object of this work is to study problems of information retrieval for a small library, the Department of Computer Science Library. Programs will be developed for providing indexes of various kinds. Report generators for new books, overdue books, etc. will be constructed. Some experimentation with on-line subject matter searches will be done. The extent of this experimentation will depend on the amount of material that can be put into machine-readable form. (L. D. Fosdick)

1554-57018 T Education. Clique Analysis of Communication Structure of the College of Education. The purpose of this study is, by means of sociometric (clique) analysis, (1) to identify to whom college staff members relate within the college, how frequent are these communications and what is the nature of the content; (2) to investigate as to whether the move to the one building will cause the staff to communicate with the same persons or choose new ones because of their proximity; (3) to compare stability of linkages to positions having the same persons in them at both times with the stability of linkages to positions having different persons in them at two different times; (4) to compare stability of linkages for a selected sample of the population for data collected six months later. (Anderson)

1555-57020 Institute of Labor and Industrial Relations. Studies in Job Satisfaction. The main emphasis of the analysis will be on the calculation of the first four moments of a number of distributions in order to calculate the norms for the scales on which these distributions are based. These norms will apply to a measure of employee job satisfaction developed at Cornell University and will allow users of this measure to more meaningfully interpret their results. The norms will give employee satisfaction according to age, job level, and other relevant characteristics. (Charles Hulin)

1556-57021 T Physics. Metal ESR Lineshape. The computer is to be used to evaluate theoretical expressions for the electron spin resonance power absorption in metallic particles. For particles much smaller than the skin depth, the lineshape is Lorentzian. For the intermediate and large particle regions, complicated asymmetric expressions exist. Since the derivative of the power absorption is measured, it will be necessary to perform numerical differentiation of the intermediate and large particle lineshapes. Experimental Lineshapes will be fit by adding a small fraction of a pure Lorentzian form to the large particle lineshape or by using the intermediate region Lineshape. The mathematic expressions depend on a single variable and on a parameter which must be varied through rather large limits. (J. R. Asik)

1557-57022 T Music. Music Evaluation MFLS. The purpose of this problem is to obtain an analysis of variance among three groups of elementary school pupils and four groups of junior high school pupils on selected test scores. The covariance is based on test scores on the Iowa Test of Basic Skills. (Robert J. Tuley)

1558-57023 Physics. Angular Correlation Analysis. In an angular correlation experiment, the coincidence counting rate as a function of angle is predicted theoretically to be given by an expansion in Legendre polynomials. The coefficients of the polynomials and the highest order polynomialwhich appears depend upon the internal parameters of the nucleus

which is involved. The usual procedure for experimental determination of the coefficients involves measurement at several angles at equal intervals and extraction of coefficients by the method of least squares. A possible fault of this procedure is that the angles are chosen only for convenience and without regard for the relative effectiveness of different angles in the ultimate determination of the coefficients. A proposed alternative procedure would extract the coefficients by integration, making use of the orthogonality of the Legendre polynomials. The integration must be performed numerically, since the experimental counting rate can be measured at only a finite number of values. Gaussian quadrature is the most obvious choice of method, since for a given number of points it can integrate exactly the highest order polynomial, compared to other methods of numerical integration. The angles for measurements are then fixed to be those of Gaussian quadrature. No experiments have even been performed at those angles. The proposed computer problem is to perform a great many simulated experiments at both the usual equal-interval angles and the Gaussian angles. The simulated data of each simulated experiment will be generated in an appropriate distribution by using pseudo-random numbers in a uniform distribution. Each experiment will be analysed into coefficients both by least squares and by direct solution. The sets of analysed simulated experiments will then be compared to determine which method more accurately determined the coefficients for a given total number of counts, i.e., which method will be more efficient when employed in an actual experiment. (John M. McKinley)

1559-57024 Social Work. Clinical Social Study. The problem of interest is the development by social workers of an orientation or structure of attitudes toward their field. Questionnaire responses are being gathered from social work students at different stages in training in different schools, and from experienced social workers. The questionnaire includes about 60 items already tested for validity. Over the next year a total of some 1500 questionnaires will be completed.

Computer services will be used to determine whether a stable attitude structure does in fact manifest itself, and if so, to determine the correlates of this attitude structure. Correlation programs and principal

axis factor analysis would be applied to returns from different groups of respondents. If justified by the results of this analysis, factor scores will be computed and will be used in conjunction with selected biographical data for analysis of change between different parts of the career, taking related factors into account. Correlation, analysis of variance, and joint distribution analysis programs would be used in the last part of the analysis. (Taber)

1560-57025 Educational Administration. Adult Attitude Toward Schools. In this particular problem a method was needed to determine the degree of discrimination (if any) that thirty-two attitude statements would have on four groups of adults (two male, two female). These adults were divided on the basis of whether they had children attending private or public school. Five separate comparisons needed to be made of the responses to these statements. These comparisons were made on the following basis: male private school to male public school; female private school to female public school; male-female private school to male-female public school; male private school to female private school; and male public school to female public school. Multiple discriminant analysis was selected as the method to make these comparisons. (Lloyd E. McCleary)

1561-57026 T Physics. Superconductor Electromagnetic Response. The problem consists of an investigation into the part which collective excitations may play in electromagnetic absorption in superconductors. It is necessary to evaluate the electromagnetic response function K(k,w) both for pure superconductors and those with a finite mean free path; k is the wave vector and w, the frequency. K(k,w) is then used to find the reflection coefficient $D_{ref} = 1 - \frac{c}{\pi} \mathrm{Re}\, Z$, where Z, the surface impedance, is given by $Z = \frac{4\pi^2 w}{c^2} \left\{ \int_0^\infty \ln [1 + k^{-2} K(k,w)]\, dk \right\}^{-1}$

Dref for the superconductor is then compared to that for the normal metal.

Calculating Re Z requires evaluation of $\int_0^\infty \ln |1 + k^{-2} K(k,w)|\, dk$, and the solution of $1 + k^{-2} K(k,w)$ as a function of k for its zero and its pole.

The integrations will be carried out by a Gauss quadrature method. A subprogram must be found to evaluate $\sin^{-1}$ (and $\sinh^{-1}$) to high accuracy. (E. J. Aspnes)

1562-57027 T Food Technology. Baterial Endospore Germination Kinetics. The bacterial spore germination curve has been shown to fit the equation $Y = e^{-kt^{-c}}$ where Y is the normalized spore refractility change, t is time and k and c are constants determined by pre-germinative treatment and conditions during germination.

The computer will first perform a linear regression on the transformed variables $\ln \ln {}^{1}/Y$ and $\ln t$ to fit the equation

$$\ln \ln {}^{1}/Y = -c \ln t + \ln \ln {}^{1}/Y_o$$

where Y_o is equal to Y at t = 1 and $\ln {}^{1}/Y_o = K$. The intercept and slope estimates from this will then be used as initial parameter estimates to a program utilizing a modified Newton-Raphson method of curve fitting by least squares. Standard errors will be computed using these final estimates. The parameters k and c will then be used to determine the maximum germination rates by equating the second derivative of the initial equation to zero.

$$\frac{d^2y}{dt^2} = KcY \left(\frac{Kc}{t^c} - c - 1\right) \left(\frac{1}{t^{c+2}}\right)$$

The t calculated from this will then be substituted into the 1st derivative

$$\frac{dy}{dt} = \frac{KcY}{t^{c+1}}$$

to achieve the maximum rate expression. (Anthony Cutaia)

1563-57029 T Physical Education for Men. Analysis of Effects of Exercise on Expiratory Capacity. Four parameters of expiratory capacity were measured before and after the treatment of 16 middle-aged men subjects with a noon-hour exercise program through the period October to May 1964-1965. The experiment will test the acute and chronic facilitation of these parameters by means of an analysis of variance technique. Since the parameters used are new and the data were obtained on the same subjects throughout, a correlational analysis will be made of various ways of handling the raw data to discover which methods produce greatest reliability. At the same time the data will be related to various simple anthropometric and functional measures on the subjects. (Michael John Ellis)

1564-57030 Mechanical Engineering. Techniques for the Numerical Solution of the Diffusion Equation. Various techniques are being analyzed for speed and accuracy in obtaining numerical solutions to the diffusion equation. The finite difference schemes being employed have either been suggested in the literature or have been derived by the principal investigator. They are variations of schemes presently being employed. (A. M. Clausing)

1565-57031 Nuclear Engineering. Multi Group Reactor Calculations Using a Modified SNG Code. The subject of the investigation being conducted in this problem is a detailed analysis of the neutron flux in a cylindrical reactor. The flux will be determined by a modified SNG code capable of handling 50 energy groups, 100 radial points, 4 mixture regions and 8 angular increments. Different cross section data developed by various research centers will be used in a specific reactor calculation. The resulting fluxes and critical dimensions will be compared. In addition to this comparison of different group cross sections, the fluxes will be used to determine the Fermiage, few groups constants, etc.

The SNG code was developed by B. Carlson at Los Alamos. The SNG approximation assumes linear variation of the directional flux between both angular and spatial interpolation points. It then solves the Boltzman equation for a given energy group assuming the inward directed flux at the boundary of the reactor = 0 and symmetry at the center. To do this it uses an iterative procedure for the radial and angular grid points. These results are then iterated for the minimum energy groups and the whole process iterated until a critical radius for a given reactor configuration is determined. (A. B. Long)

1566-57032 Department of Computer Science. General Utility. This Utility Problem will have three main objectives. They are (1) to copy tapes on the 7094, especially involving CalComp output, (2) to compare output from problems on ILLIAC II with problems from the 7094 as necessary, and (3) to examine and adapt 7094 tape tests as needed for simulation on ILLIAC II, the object being that of making Customer Engineering on ILLIAC II easier. (W. L. Huffman)

1567-57033 T Economics. Product Diversification in Manufacturing. With the aid of the frequency counting merge-sort program, the extensiveness of diversification of various business firms in 1962 will be computed. This will be compared with published data for earlier periods. The correlation program will be used to determine some of the significant characteristics of diversified firms. The multiple correlation or stepwise multiple correlation program will be used to test whether or not diversified firms have accomplished their stated objectives for diversifying. The same technique and program will be used to determine the more significant determinants of diversification. (Donald F. Eslick)

1568-57034 T Sociology. Political Involvement of Professors. It is the purpose of this study to ascertain the degree to which a selected group of professors at the University of Illinois are involved in the political process. Four aspects of the problem of the relationship between academic career and political involvement will be investigated: (1) the effect of the professor's occupational milieu and style of life on the extent of political involvement; (2) the nature of the relationship between the individual's level of formal group participation in the community and the level of his political interest and participation; (3) the correlates of certain demographic factors and political involvement; (4) the relationship of certain attitudinal factors and political involvement.

The standard programs in SSUPAC will be appropriate for analysis of the data. The computer will facilitate the computation of simple frequencies, chi square, analysis of variance, simple correlation and the standard error of difference between mean proportion. (Lynn J. Loughrey)

1569-57035 Industrial Education. Practical Nursing Study. This problem is a two-state study of practical nurse programs, selection, recruitment, and occupational patterns. The analysis will be done with programs available from the Bureau of Institutional Research such as Data Screening, Correlational Analysis, Factor Analysis, and Chi Square. (Tomlinson)

1570-57036 T Physical Education for Men. Vertical Deflections and Mile Run Correlations. The prime objective of the problem is to obtain the correlations between mile run time and each of 34 variables, most of them vertical deflections of five types of cardiovascular parameters (waves). The correlations program will be used for this purpose (Pearson Product-Moment Correlation). The intercorrelations between the variables will also be derived from the correlations program.

The reliability (test-retest) coefficients of each of the variables can also be computed with the correlations program, although this involves the use of a different data deck.

Also, multiple correlation will be run to best predict the 35th variable, mile run time. (Chris Milesis)

1571-57037 Botany. Fluorescence Spectral Analysis. The emission and excitation spectra of fluorescence from photosynthetic plants is measured by an automatic spectrofluorometer built in the Botany Department, University of Illinois. These measurements call for corrections since the sensitivity of photomultipliersand the efficiency of monochromators is not uniform with varying wavelength of light. It takes months and years to correct all the curves obtained in the above research by the use of usual procedures. The use of the computer simplifies this task enormously and saves time. The mathematical methods involved are simple multiplications and divisions. (Govindjee)

1572-57039 University High School. UICSM Data Analysis. The purpose of this research is to develop an integrated set of methods appropriate for use by educational curriculum projects for analyzing data from instructional tests. Short answer items as well as so-called objective items are to be accommodated. Emphasis is upon identifying individuals attaining mastery rather than upon average performance of groups. The computer is used primarily for counting and classifying, secondarily for calculating. (M. Tatsuoka)

1573-57040 Botany. Photosynthesis Data Analysis. The problem to be presented to the computer is the treatment and analysis of a large volume of fluoresence data obtained by measurements made on various photosynthetic systems. The data is in the form of a series of fluoresence values for a given series of wavelengths. A data set is equivalent to one fluoresence spectrum and consists of about 500 different values. Each run involves the treatment of about 20 data sets.

The steps involved in the data treatment are: 1) cleaning up of data; 2) application of several correction and normalization factors, e.g. allowing for the wavelength dependence of the photomultipliersused to detect and the light source used to excite fluoresence; 3) production of a differential spectrum by calculation of slope; 4) integration and final total area under curve computation.

The data is then used in an attempt to analyze the corrected spectrum into curves due to the different pigments present in various photosynthetic systems. (Williams)

1574-57041 Sociology. Parole Board Perspectives. The 7094 will be used for an analysis of questionnaires sent to 249 parole board members throughout the United States, to obtain responses on their experience, policies, and practices. Mathematics on the machine will be of a simple nature; primarily gross tabulations and frequency counting will be used. (Daniel Glaser)

1575-57042 T Physical Education for Men. Thesis Problem-Fitness of Postal Employees. The problem at hand is the comparison of selected physical fitness measures of post office carriers and clerks. The means of both groups were compared on forty-four different measures.

The computer will be used to run an analysis of covariance statistic to compensate for the significant difference in the age of the two groups. The two groups were Urbana, Illinois post office carriers and clerks. There was a total of twenty-two subjects: twelve carriers and ten clerks. All subjects volunteered for the study.

The research hypothesis was that the carriers would show superior results in the selected measures. However, the statistical hypothesis was that the two groups were equal. (Gary Skrinar)

1576-57045 State Water Survey. Deterministic Component of Monthly Runoff. This program will compute the daily baseflow discharges, q_1, and the total monthly runoff, R_1, represented by the recession curve of baseflow. These quantities are termed the "deterministic" component of the runoff. The input data will consist of: the beginning-of-month baseflow, q_1, and the slopes of the recession curve, K_b, for various ranges in discharges, q_b. Routines prepared by the Illinois State Water Survey will be used. (Robert Sinclair)

1577-57046 T Electrical Engineering. Plot Assist. This research is concerned with the display characteristics of a monopulse radio direction finding system. This system has been simulated on a digital computer and the results have been obtained in the form of data punched on cards. The data represent the response of the system under a wide range of operating conditions. The remaining task is to put the simulation results already obtained into graphical form. The ILLIAC II system is capable of preparing output tapes to be used to drive a CalComp incremental plotter. This plotter will be an ideal tool for efficiently and accurately constructing the graphs. (Stephen Rosenbaum)

1578-57047 Zoology. Tree Sparrow Calorie Experiment. Tree sparrows were fed experimental diets while maintained under a series of different environmental conditions in the laboratory. The experimental treatments involved were as follows: (1) nine special diets formulated to provide three metabolizable energy levels and supply isonitrogenous intake at the three different environmental temperatures; (2) three photoperiods of 10, 15, and 19 hours duration; (3) three temperatures of -14°, 23°, and 30°C. The experimental design which served as a basis for the experiment was a split-split plot factorial design.

The computer will be used to generate certain products to be tested by least squares procedures. (Elden W. Martin)

1579-57048 T Economics. Factor Analysis Wage Shares. A principal axis factor analysis of the intercorrelations of the relative wage shares of 17 U.S. manufacturing industries will make it possible to test in an efficient way the empirical relevance of some hypothetical explanatory variables, suggested by the neoclassical theory of income distribution. Furthermore, a varimax rotation of the initial factor axis will simplify the analysis. (Paul Van Rompuy)

1580-57049 Department of Computer Science. Threshold Logic LP I. The purpose of the problem is finding threshold functions out of all Boolean functions. The program consists of the following steps: (1) generation of functions which are likely to be threshold functions. (2) testing of the above candidate functions by linear programming to find whether they are actually threshold functions. (Saburo Muroga)

1581-57051 T Chemistry and Chemical Engineering. Molecular Scattering Processes. The study of atomic and molecular scattering problems involves the solution of coupled integro-differential equations. These equations may be solved by an iteration process for "weak" scattering potentials which do not perturb the scattered particle much. The S matrix may be constructed for a "strong" potential from that for the weak ones by simple matrix operations. (Don Secrest)

1582-57052 T Agricultural Economics. Fresh Fruit and Vegetable Marketing in Chicago. The consumption of fresh fruits and vegetables in Chicago has been declining while the consumption of frozen fruits and vegetables has increased. Trends elsewhere in the U.S. are similar.

In order to appraise the effect of these changes income elasticities will be computed from cross-sectional data and trends in the fresh-frozen ratio will be computed for regional data.

These calculations will require various correlation and multiple correlation routines from SSUPAC. (Jim Macmillan)

1583-57053 Electrical Engineering. Helical Dipole Phased Array. The electromagnetic radiation patterns for a helical dipole phased array will be calculated using the technique of pattern multiplication. That is, the patterns will be determined by taking the product of an individual helical dipole pattern and the pattern of a set of isotropic sources with proper phase and amplitude distribution. The effect of altering the various physical and electrical parameters of the system upon its radiation characteristics will be studied. (Andrew J. Poggio)

1584-57054 T Physical Education for Men. Comparison of Physical Education Activities for Young Boys. The purpose of the statistical analysis is to determine the significance of differences from T_1 to T_2 for each year (62-63; 63-64; 64-65) between each combination of years (62-63 vs 63-64; 62-63 vs 64-65; 63-64 vs 64-65) on each of 9 variables. as relating to the American Association of Health, Physical Education, and Recreation Physical Fitness Test Battery. 1) Start with differences ($T_1 - T_2$) for each year on each variable. 2) Compute $\bar{X}$ difference between each combination of years (i.e., 62-63 vs 63-64; 62-63 vs 64-65; 63-64 vs 64-65) on each variable. 3) Compute standard deviation of differences for each year. 4) Compute standard error of mean differences for each combination (see 2). 5) Compute paired sample "t" test for each combination, i.e.,

$$t = \frac{\bar{X}_1 - \bar{X}_2}{S\bar{x}_1 - \bar{x}_2}$$

(G. D. Hembrough)

1585-57055 Food Technology. Quality of Sweet Corn by Maturity. The problem involves finding one or a few rapid objective tests for determining optimum sweet corn maturity. Two such tests have been developed. One is a density determination as an indirect measure of moisture content and the other is a refractive index reading as a measure of sweetness. The experiment was performed over two seasons each of which included two plantings of each of two varieties. Periodic harvestings were made and the samples were tested by the new methods, conventional objective methods, and subjective methods. By means of a standard computer program, the

degree of correlation between the various maturity methods and the organoleptic quality will be determined. From this the validity of the new methods and the maturity index calculated from them will be ascertained. The ultimate benefit will be higher quality at lower cost to the consumer. (M.P. Steinberg)

1586-57056 Physics. Nuclear Charge Distributions. The object of the calculation is to obtain the nuclear charge distributions predicted by the shell model. Nuclei with mass numbers in the range A = 12 - 80 are of interest, so the single particle potential to be considered is that used in optical-model scattering:

$$V(r) = - V_o \left\{ 1 + \exp \left[(r - r_o A^{1/3})/a \right] \right\}^{-1}.$$

The numerical problem is to find the eigenvalues and eigenfunctions of the radial Schrodinger equation

$$U''_{n\ell}(r) + \left[-K^2_{n\ell} - V(r)\,(2m/\hbar^2) - \ell\,(\ell+1)\,r^{-2} \right] U_{n\ell}(r) = 0$$

(with $U_{n\ell}(0) = 0$, $U_{n\ell}(r) \longrightarrow 0$ as $r \longrightarrow \infty$) for the single-particle orbitals appropriate to each nucleus. The procedure, of a series expansion of $U_{n\ell}(r)$ for small r followed by numerical integration of the differential equation out to a value of r where $U_{n\ell}(r) / U_{n\ell}(r)$ can be matched to known exterior solutions, closely follows currently used codes for the corresponding problem in mu-mesic atoms. An iterative scheme for successive trial values used there with success (5 iterations, starting with K^2 accurate to about 20%, produces eigenvalues accurate to better than 4 parts in 10^6) will be tried, and modified if necessary.

The quantity of interest, the charge density, will be $r^{-2} U^2_{n\ell}(r)$, times an appropriate weight factor, and summed over the filled orbitals (i.e. values of n and ℓ). The repetitive part of the problem consists in examining the influence of the parameter V_o in V(r) (assuming that r_o and a are known), and also of its variation with A. The immediate object is to compare the predictions of the nuclear shell model with the charge distribution differences among the calcium isotopes ($Ca^{40,44,48}$) measured experimentally by means of high-energy electron scattering. (J.M. McKinley)

1587-57057 Mechanical Engineering. Cavity Reasonace. The propagation of nonsteady sound waves in an infinite medium is described in terms of a wave front function by the eiconal equation. This is a first-order non-linear partial differential equation. For the case where a "wind" exists in the medium (or rather a boundary layer along a plane of a semi-infinite medium) the solution of this equation is extremely difficult by any means. A method is developed for computer use by dividing the medium into a number of sublayers where the "wind" velocity and temperature are assumed constant. By applying Snell's Law at even interface and tracing individual rays, the wave front propagation may be successfully traced. (Robert A. White)

1588-57058 T Electrical Engineering. Radiated Power from a Dipole in a Plasma. The problem being investigated is the radiation resistance of a dipole antenna in a magnetoplasma. Although a "power density" function can be found by conventional techniques, finding the radiation resistance involves integrating this "density function" which must be done using computer techniques. The one dimensional integral involved is performed using conventional computer integration techniques. (Douglas Ken Waineo)

1589-57059 Health Service. Maternal Overprotection. The study attempts to investigate the relationship between maternal overprotection and indulgence, and emotional adjustment. Control and experimental groups are rated on twelve questions. Each question has a six-point scale. T-tests are run for each question between the two groups, and according to sex and number of siblings. The significance of the average differences between the two groups is to be investigated, for every question. (Nikelly)

1590-57060 Mathematics. Solutions of Diophantine Equations. Solution pairs (x,y) of small modulus ($|x| \leq 1000$) will be sought in the Gaussian integers for the equation $x^2 + 2 = y^3$. A two dimensional search procedure and modular arithmetic will be employed. (Mark P. Hale, Jr.).

1591-57061 Civil Engineering. Residual Stress Study. The problem is concerned with the determination of the residual stress pattern existing in a welded steel plate. The computer will be used to convert measured surface strain changes, which occurred as the plate was sectioned and sliced, into the pattern of stress which existed in the plate before it was cut. (Nelson Funston)

1592-57062 T Chemistry and Chemical Engineering. NMR Lineshape Analysis. The problem being studied is determination of rates of chemical exchange by NMR lineshape analysis. This is done as follows: an experimentally determined lineshape is presented to the computer as a set of digitized absorption intensities at arbitrary frequency intervals. Also an estimated exchange rate is presented and theoretical intensities are calculated corresponding to arbitrary increments both greater and smaller than the estimated rate. The set of theoretical intensities corresponding to each rate is compared with the experimental set and the sum of squared deviations in intensity is calculated. The program then determines which theoretical set of intensities gives the best fit of the experimental data, and the rate corresponding to this best theoretical set is printed out. (S. Zumdahl)

1593-57063 T Civil Engineering. Cavity Flat Face. Field studies of stress and displacement around underground cavities have been made. The purpose of the computer program is to obtain elastic-plastic solutions for comparison with the field values. A finite element method will be used. Both axisymmetric and plane strain cases will be studied. Most of the computer time will be used in the solution of specific problems, as the program has already been checked for various boundary conditions. (Ed Cording)

1594-57064 Chemistry and Chemical Engineering. Enzyme Kinetics. The rate equations for enzyme catalysed reactions tend to be complex nonlinear functions of reactant concentrations. Much can be learned about the mechanism of an enzymatic reaction by determining the form of the rate equation, and by examining the actual values of the kinetic constants and checking the relationships between them. Programs have been written in Fortran language to make least square fits to various possible equations describing the kinetic course of enzymatic reaction. The computer facilities would be used to analyse kinetic data for a group of enzymes concerned with the degradation of camphor, in order to better characterize these enzymes and elucidate their mechanism of action. (Richard Prairie)

1595-57065 T Zoology. Minimum Distances Between Crayfish. As part of a study of aggressive behavior in crayfish, minimum distances between individuals at different population densities will be computed. The program takes the coordinates of each individual and then calculates the distance from every other individual in the group. The minimum distance maintained between individuals is then found. Mean and standard errors are also calculated. A least squares curve will then be computed for the data. (H. William Lunt)

1596-57066 Civil Engineering. Study of Closures for Launch Facilities. Various closures for missile silos are to be analyzed to determine their response under extremely high static as well as dynamic overpressures. The material properties are represented by perfectly elastic as well as elastic-plastic stress-strain laws.

Because of the shapes and boundary conditions of the closures, as well as the nonlinear material behavior, closed-form solutions are not possible for this problem. Consequently a discrete model which is mathematically consistent with a central finite difference analog of the continuum equations is employed to simulate the inertial and geometric properties of the continuum. The material behavior is specified by means of the appropriate constitutive relationships.

For the dynamic problems, the equations of motion are integrated by means of a noniterative numerical procedure, whereas for the static problems the set of equilibrium equations are solved by a Gaussian elimination process. (Hans Rainer)

1597-57068 T Physical Education for Men. Cardiac Intervals Related to Age. The problem was designed to determine the relation of age to certain cardiovascular variables. Simultaneous brachial pulse waves, electrocardiograms and ballistocardiograms were recorded in sixty female subjects ranging in age from 13 to 59. Four intervals were measured at rest, and three times during recovery from exercise. Tests were repeated three times.

Reliability (Pearson Product-Moment Correlations) will be obtained for all variables between T_1 and T_2, T_2 and T_3, and T_1 and T_3. All variables will be correlated (Pearson Product-Moment) with age of subject. (Mary Lou Whitwill)

1598-57069 T Education. Perceptual Relationship Between Ideal-Self versus Real-Self. The purpose of this study is to systematically investigate the relationship between the ratings of the ideal-self versus the actual-self among and between persons interacting in an educational environment.

This study will be limited to the evaluation of rating scores as reported by administrators and teachers on the Occupational Characteristic Index for the self-actual versus the self-ideal rankings of the following: 1. administrators' ratings of actual and ideal administrators, 2. administrators' ratings of the actual and ideal teacher, 3. teachers' ratings of the actual and ideal administrator, and 4. teachers' ratings of the actual and ideal teacher.

The instrument to be used is the Occupational Characteristic Index which was devised by Dr. Ray Simpson, Professor of Educational Psychology, University of Illinois.

The statistical treatment will use the t test for differences between means for independent samples for each of the six Bi-Polar clusters as measured by the OCI.

Where significant differences among the six Bi-Polar clusters do occur, it is contended that this constitutes an area for possible role conflict. (Sapone)

1599-57070 T Physical Education for Men. Total Peripheral Resistance-Correlations. Total Peripheral Resistance, as conceived by Wiggers, a cardiologist, is being tested on men and women 25 to 65 years of age, using data which have been collected in the Physical Fitness Research Laboratory, at the University of Illinois, under the supervision of Professor T. K. Cureton. The tension in the vascular system is being measured. It is not known whether the sample of women is more relaxed than the sample of men but this study will test the hypothesis that women are relatively more relaxed. Such a factor, if found to be significant, may have a relation to heart disease, and further studies may be made to bring this out.

The biserial correlation is sought between the men's data and the women's data. Also, two formulae relating pulse rate, blood pressure, and stroke volume to total peripheral resistance are being compared to determine their relation to each other. (Lang)

1600-57071 Physics. Eigenvalue of the Bethe-Salpeter Equation. A Bethe-Salpeter equation for spinor particles is reduced to a system of four coupled differential equations. Choosing suitable boundary conditions at $\pm\infty$ for the solutions of these equations, an eigenvalue problem is obtained. The computer is used to resolve this eigenvalue problem in the following way: 1) Computing the permitted solutions at $-x_{min}$, $+x_{max}$ from a series expansion, starting at $\pm\infty$. The convergence of this series expansion is checked. 2) Resolving the system of differential equations numerically from x_{min} to x_{max}. The obtained solutions permitted at $-x_{min}$, should be a linear combination of the permitted solutions at $+x_{max}$. This is accomplished if a suitable determinant is equal to 0. The value of this determinant and of its derivative, with respect to a parameter in the equations, is evaluated. By the Newton-Fourier method the value of the parameter for which the determinant is 0 is evaluated in an iterative way. (G. Patergnani)

1601-57072 T Civil Engineering. Capacity and Deflecticns of Reinforced Concrete Slabs. The program deals with the computation of the capacity and deflections of reinforced concrete slabs. During the testing of these slabs, photogrammetric pictures are taken of the deflected surface at each

stage of the load. The surface of the slab is provided with a system of axes of reference, and a network of points. These pictures are interpreted in a stereo-photogrammetric equipment which provides the x and y coordinates of all the points of the network on the surface of the slab. From the characteristics of the camera, the z coordinate is evaluated by the computer program. Furthermore, by using finite differences, the curvatures along the axes of reference and the capacity and deflections of the slab at each stage of loading are evaluated. (Rolf Lenschow)

1602-58001 Psychology. Analysis of Speech Similarities in Clinic and Non-Clinic Samples. Three minutes of free speech was analyzed for clinic families and non-clinic families (father, mother, and son). For each member of both groups the average pause and action length, the median pause and action length, and frequency of pauses were found. The inter-correlations between these independent variables and the age, intelligence scores, social-economic status, and education of each subject are needed, plus an analysis of variance for the independent variables. (Judy McArdle)

1603-58003 Nuclear Engineering. Monte Carlo Solution of Source Energy Degradation. The problem involves the analysis of a Cobalt 60 source contained in a cylindrical pig. The purpose of this analysis is to determine the angular distribution and the energy distribution on a plane located at some known distance above the source.

The method of solution is the Monte Carlo technique. (Chilton)

1604-58005 Nuclear Engineering. Calculation of Vapor Reheat Distillation Process. Thermodynamic calculations of the Multi-Stage Vapor Reheat Distillation Process will be made, with the purpose of determining the optimum operating conditions for a given environment. Multi-stage plants of up to 50 stages will be considered, using second-order approximations on specific heats and heats of vaporization. A sub-program will be used for the final selection of the optimum plant from economic considerations. (E. F. Janzow)

1605-58006 T Aeronautical and Astronautical Engineering. Perturbation Solutions for Laminar Boundary Layer with Transpiration. In obtaining perturbation solutions to the problem of the laminar boundary layer with transpiration, it is necessary to first solve two third order ordinary differential equations. The equations are respectively the Blasius equation, $f_o''' + f_o f_o'' = 0$, and the corresponding perturbation equation $N''' + f_o N'' + \lambda f_o' N' + (1-\lambda) f_o'' N = 0$. For the numerical solution of these equations, in general the equations will be approximated as $y''' + B_2 y'' + B_1 y' + B_o y = 0$ where B_i are constant. By taking the Laplace transform and its inverse, the solution to the preceding equation is $y = C_1 + C_2 \tau + C_3 \frac{\tau^2}{2!} + \ldots$ where $C_i = [A_{3-i} - \sum_{j=0}^{2} B_j C_{i+j-3}]$ and $A_2 = y(o^+)$, $A_1 = y'(o^+) + B_2 y(o^+)$, $A_o = y''(o^+) + B_2 y'(o^+) + B_1 y(c^+)$. Therefore for a step increment of Δt, $g(t+\Delta t) = C_1 + C_2 \Delta t + C_3 \frac{\Delta t^2}{2!} + \ldots$. Finally an iteration is performed by computing the C_i and B_i using $y = \frac{[y(t) + y(t+\Delta t)]}{2}$ in the B_i constants. This method has been found to exhibit good accuracy with high computational speed when used under various conditions at the Boeing Aircraft Company. (T. E. Edwards)

1606-58008 Education. Discussion Item Feedback. An analysis of student performance in the rating of discussion test items under different conditions related to the use of model answers and instructor evaluation is intended. Feedback techniques will be varied and analyses will utilize standard routines of correlation and analysis of variance. (C. M. Garverick)

1607-58009 Psychology. Verbal Hypotheses and Intentions. This study examines the effect of affective and distributional parameters of a reinforcer on six private report measures, two response selection measures, and a number of derived scores. The computer is used to obtain 18 4x3 analyses of variance, an 18x18 correlation matrix, a 20x20 correlation matrix, and 13 individual correlations of x and y for subjects at theoretically specified values of z. (Dulanyde)

1608-58010 Civil Engineering. Mathematical Model of Watershed Flow Phenomenon. The flow of surface water from a watershed may be treated as spatially varied flow with increasing discharge. Formulation of this equation in conjunction with the continuity equation produces a pair of quasi-linear hyperbolic partial differential equations. A solution of these equations for various boundary conditions may be obtained by expressing the governing equations in finite difference form and using an explicit (marching) method of solution. Convergence of the solution is insured by maintaining the time step within the domain of dependence. Evaluation of depth and velocity for 800 points on each time level allows almost complete description of the flow behavior within the watershed boundaries. The need for high-speed computer evaluation is a prerequisite since up to 200,000 points will have to be evaluated under certain conditions. Results from this program will allow prediction of the discharge to be expected from a watershed under a given set of known conditions. The ability to vary the boundary conditions should provide an insight into the influence of the many factors which affect the discharge of a given watershed. (T. E. Harbaugh)

1609-58011 T Economics. Analysis of Locational Change. The research problem involved here is that of tracing the factors responsible for the locational changes observed in the Agricultural Implement Industry over the period 1850 to 1900. A measure of locational change, called the net shift technique, is used to measure change in location in the Agricultural Implement Industry and in a number of other factors which appear to favor changes in location of that industry. The computer will be used to run multiple correlation coefficients and partial correlation coefficients to try to isolate the key factors responsible for the locational changes in this industry. (Harvey Schwartz)

1610-58012 Dairy Science. Behavior Genetics Research. The differential effects of prenatal maternal stress on offspring behavior in inbred strains of mice are being investigated. Data resulting from this research will be subjected to various statistical analyses on the computer. (J.C. Defries)

1611-58013 Mechanical Engineering. Safety of High Temperature Systems. This problem is an investigation of the temperature distributions in steam and water jets. The jets are formed by expanding steam and water into the atmosphere through a nozzle.

The computer will be used to reduce the data and to fit curves. (C. P. Armstrong)

1612-58014 T Mathematics. Two-Armed Bandit. Concerning the sequential decision problem known in statistics as "the two-armed bandit", computations will be made of the results of using various possible strategies under different values of the probability parameters of the problem, for the purpose of gaining information and insight useful in the search for optimal strategies. Results under particular strategies will be obtained through actual probability calculations; no random number techniques will be used. (D. J. Gans)

1613-58015 Civil Engineering. Consolidation of Deep Sea Sediments. The problem being investigated is the one-dimensional consolidation of a clay layer increasing in thickness.

The governing partial differential equation for the excess pore pressure U is

$$C_v \frac{\partial^2 U}{\partial X^2} = \frac{\partial U}{\partial t} - \gamma' \frac{dh}{dt}$$

where: C_v = coefficient of consolidation
γ' = submerged unit weight of soil
X = distance from lower boundary of clay layer
h = thickness of clay layer

and:

$U(h(t),t) = 0 \qquad t > 0$

$\frac{\partial U}{\partial X}(0, t) = 0 \qquad X = 0,\ t > 0$

$U(x, 0) = f(x) \qquad 0<x<h(0)$

Because the time-thickness relationship can seldom be expressed analytically and even when possible, closed form solutions exist only for a few special cases, the first equation is transformed into a difference equation for a numerical solution.

The effect of C_v on U will be studied by using different values of C_v. The effect of a variable C_v will be investigated pending outcome of initial results. (John Lai)

1614-58016 Physics. Kinetics of Quenched-in Vacancies. The computer will be used primarily for solving simultaneous differential equations, curve fitting, and general data analyzing using arithmetic, algebraic, differential, and integral techniques in conjunction with an investigation of the kinetic properties of quenched-in vacancies in gold. (Kino Takao)

1615-58017 T Chemistry and Chemical Engineering. M.O. Calculations on Lewis Acid-Base Systems. The problem being studied is: Hoffman-Lipscomb type molecular orbital calculations on a number of Lewis acid-base systems. The program employs the Jacobi Method for diagonalization of a matrix whose limiting dimensions are 120 x 120. In addition, a Gram-Schmidt orthogonalization is used on another matrix. Basically, the requirement for the computer is not in the exotic or unique type of calculation employed, but for the extended nature of the calculation. (Donald H. Dugre)

1616-58018 Zoology. Bioenergetics of Animals. A study is being made of the energy requirements of birds, mammals, and other animals for existence, migration, reproduction, and other activities. Curves of metabolized energy need to be fitted against weight, temperature, activity, etc., by the method of least squares. (S. C. Kendeigh)

1617-58019 Mechanical Engineering. Dynamics of Machine Systems With Fluid Transmission Lines. The principal objective of this investigation is the dynamic analysis of machine systems, such as the computer controlled machine tools which contain elaborate hydraulic power and signal networks.. In order to achieve the synthesis of such systems extensive computations of lumped and distributed parameter characteristic response for the individual components and assemblies are required. The computer will be used to generate the numerical solutions of the characteristic equations, and perform the mechanical impedance computations for the entire system. Of special interest are the influence of structural component stiffness on the pressure pulse, the phase relationships during cutting operation and the components configuration factors (weight - stiffness ratios).
(B. F. Vonturkovich)

1618-58020 Survey Research Laboratory. Kish-Hess Program. Cost and time considerations involved in large-scale studies require that interviews be clustered in small, geographical areas which are representative of a certain portion of the population of Illinois. All of these selected areas together, then, are representative of the population of the entire state. The above clustering of interviews, while necessary, results in an increased variance of measurements over and above that which would result if the data were gathered from a simple random sample.

The mathematical operations involved in getting the ratio of clustered sample variance to simple random sample variance are simple to obtain, since only sums of squares and different sets of cross products are involved. It is the large number of these operations and the necessary combination of these terms which make a computer program necessary. (Bernard Lazerwitz)

1619-58021 Agronomy. Employment of Agronomists. A yearly summary of domestic and foreign students graduating in Agronomy is to be made for the three degrees (B.S., M.S. and Ph.D) relative to their employment in 14 different areas. The 14 areas of employment range from Agriculture Business to Graduate School and Farming with from one to eight subdivisions within an area. Summaries relative to the above employment will also be run over graduates of past years starting with 1957. (Seif)

1620-58022 Chemistry and Chemical Engineering. pH Profile of Chymotrypsin Hydrolysis. The problem of this research is to develop methods for determining the groups at the active site of an enzyme that are responsible for its catalytic activity. One such method currently under investigation is the use of various reaction rate laws and their derived kinetic equations.

A computer is necessary to find the "best fit" to the different equations and to give an idea as to how reliable the fit is.

The method is that of least squaring by the Gauss Approximation Method with iteration. (S. Bosen)

1621-58023 T Physics. Solid State Detection of Helium Recoils From Photoproduction of π^o. We will analyze the reactions $\gamma \alpha \rightarrow \pi^o \alpha$ and $\gamma\ He^3 \rightarrow \pi^o\ He^3$ in the impulse approximation. In this approximation the cross sections for these reactions are equal to amplitudes of photoproduction from individual nucleons, a kinematical factor, and an integral which is the matter form factor of the recoil. The cross sections are obtained from the counting rates and the geometry of the experimental set up. To obtain the cross sections the computer will perform a numerical integration in which the integrand is the counting rate, solid angle, etc. The rest of the data is the recoil energy and angle. Using simple algebra the above kinematical factor is obtained; the obtained kinematics are then used in the formulas for individual nucleon amplitudes to compute these. Thus a form factor is obtained. Finally a wave function is assumed for the recoil. A numerical integration (if it cannot be done analytically) is performed and another form factor which should agree with the former form factor is obtained. Thus a suitable wave function is obtained. (Marvin Blecher)

1622-58024 T Physics. Silicon Lifetime Fit. Changes in the minority carrier lifetime of silicon, induced by exposure to gamma rays from cobalt 60, are to be evaluated according to the theory of Shockley and Read. This theory states that for the jth type of defect which possesses a unique energy level for electrons, the minority carrier lifetime, τ_j, of that level is of the form

$$\tau_j = A_j + B_j\, X^{-3/2}\ e^{-\Delta_j X}$$

where $X = 10^3/T$ and T is the absolute temperature, Δ_j is the difference in energy between the defect energy level and the nearest energy level in either the conduction or valence bands, A_j and B_j are parameters related to the dopant concentration, the defect density, and its capture cross section for holes and electrons.

For several defect levels the net radiation induced lifetime change is given by

$$1/\tau_{net} = \sum_{j=1}^{n} 1/\tau_j$$

where the sum is over all the different types of defects.

The computer will be used to determine the best values of A_j, B_j and Δ_j, and their probable errors, by fitting the above formulae to the experimental data. (R. A. Hewes)

1623-58025 T Theoretical and Applied Mechanics. Search for Eigenvalues in Vibration Problems. Stodola's iteration method is going to be used to search the eigenvalues and the mode of the vibration problems. Different boundary conditions of nonuniform beams are considered. (H. C. Wang)

1624-58026 T Chemistry and Chemical Engineering. Multicenter Integrals. This problem involves the calculation of two and three center integrals which represent one-electron operators in molecules. The operators include electronic field gradients, dipole moments, forces, magnetic shielding, and diamagnetic susceptibilities. The aim of the research is a better understanding of the electronic structure of molecules.

The computer will be used to program and compute the two and three center integrals by numerical techniques. (W. H. Flygare)

1625-58027 Physics. Triangle. In certain inelastic, elementary particle interactions at energies of one to a few billion electron volts, it is presumed that final state rescattering produces observable effects. One can approximate the matrix elements for such processes by elementary functions. It is then required to compute various phase space integrals in order to compare with experimental observations. These are performed numerically. (Melvin Month)

1626-58028 T Chemistry and Chemical Engineering. Heats and Entropies of Reactions. This problem involves the calculation of heats of formation, H_f, and entropies of formation, S_f, for metal ion complexes in mixed solvent medial. The method of enthalpy titrations is used in obtaining change in temperature versus milliliters of titrant (or time) curves. The computer will be used to take the raw data from these curves as input, refine them, calculate heats and entropies of the step-wise complex ion formation, and calculate a statistical mean and variance on the results. The subroutines which will be used are SELPGM, LSQ2, MATINV, FØL2, and a linear equation solver (LINSY). (William J. Randall)

1627-58030 T Agricultural Economics. Transportation Rate Structure for Illinois Hog Marketing. The nature of the research is the study of the transportation rate structures for hogs moving through Illinois markets. The computer will be used in the statistical analysis of the different rate structures of truck and rail transportation. SSUPAC programs for variance analysis and multiple correlation will be used to determine F ratios and to fit quadratic regression functions which are polynomials of the second degree. (Emer Broudbent)

1628-58031 Physics. K-Decay. The purpose of the proposed computation is to calculate the 3 pion spectrum in K^+ meson decay. This involves the solution of a set of coupled integral equations of the form

$$f_i\,(xe^{-i\phi}) = g_i\,(xe^{-i\phi}) + \sum_j \int_o^\infty K_{ij}\,(xe^{-i\phi}, x'e^{-i\phi})\, f_j\,(x'e^{-i\phi})\, dx'$$

$$f_i\,(x) = g_i\,(x) + \sum_j \int_o^\infty K_{ij}\,(x, x'e^{-i\phi})\, f_j\,(x'e^{-i\phi})\, dx'$$

Standard library routines will be used.

The parameters involved, namely the effective ranges and scattering lengths for pion-pion scattering will be varied and the theoretical Dalitz Plot calculated and compared with experiment. (Ian Barbour)

1629-58032 State Water Survey. Municipal Pumpage Program. This program is intended to provide information regarding seasonal variability of municipal pumpage in Illinois; the degree of variation associated with the three sources of supply -- ground water, surface water, and Chicago suburban; any trend in the mean yearly pumpage; per capita water consumption for various cities in the state; and any change in seasonal variability with average pumpage rate.

The monthly pumpage for the years 1962 - 64 will be used. (Robert Sinclair)

1630-58034 Animal Science. Calcium and Phosphorus Effects on Aging in Mice. The effects of calcium and phosphorus on aging in mice are being studied in terms of bone breaking strength, heart weight, etc. The data will be analyzed by the method of least squares. (B. G. Shah)

1631-58035 Education. Music Achievement Testing. The primary problem involves standardizing an Elementary Music Achievement Test developed over the past several years. Approximately 15,000 students will be tested with an instrument that has six sub-parts and norms will be provided on both the sub-parts and the total instrument. Item analysis work will be given as phi coefficients. (Richard J. Colwell)

1632-58036 State Water Survey. Streamflow Variability. The main objective in this hydrology research area is to investigate the variability of streamflow. From this it is anticipated that future streamflow can be predicted.

The mathematical techniques that are used incorporate both statistical and engineering analytical methodology and theory.

Since the research area resides in the natural environment, the model's characteristics are underlying and many factors are intercorrelated. Consequently the complexity of the model will not be described here in its entirety.

The generalized equation along with the definitions of the principal components are as follows: $y = f(X_1, X_2, X_3, X_4, \ldots X_{11})$.

Where y = monthly streamflow

X_1= Deterministic component of baseflow area under baseflow recession curve.

X_2= Total monthly baseflow.

X_3= Total monthly streamflow for preceding month.

X_4= Timing within month, or center of gravity at preceding month's flows.

X_5= Size of basin.

X_6= Slope or hydraulic geometry of stream.

X_7= Variability of preceding monthly's daily flows.

X_8= Mean of observed past monthly y's.

X_9= Std Dev of observed past monthly y's.

X_{10}= Skew of observed past monthly y's.

X_{11}= Mean of past observed X_2's (baseflow's). (Robert Sinclair)

1633-58037 T Physics. Electronic Wave Function in Alloys. The Schrödinger equation with a screened potential will be numerically integrated to obtain the electronic wave function in the vicinity of a charged impurity. The starting values will be obtained via a power series solution. Milne's method for a second order differential equation will be used. (J. R. Asik)

1634-59001 Education. Expectation-Musical Listening. The primary objective of the analysis is to find differences (if they exist) between four groups of students experiencing 4 different treatments arranged in a 4 x 4 factorial. Thirty-five measures are available on each of the groups with an experimental N of approximately 830.

Fifth grade students have participated in an experimental music program divided into four phases, phase X_1 an expectation emphasis with stress on form, phase X_2 textbook emphasis, stress on factual knowledges, phase X_3 textbook emphasis, stress on aural skills, and phase X_4 textbook emphasis with stress on keyboard performance. Measures of musical and scholastic aptitude, scholastic and musical achievement form the body of scores to be used in determining success of each program which has as its ultimate goal determination of whether certain skills and knowledges are feasible at the fifth grade level.

Simple means, variance, standard deviation and t scores will be used in most instances. One phase of the total experiment calls for a factor analysis of skills evident in experts listening to music. (R. J. Colwell)

1635-59002 Education. Keyboard Experiences. Two groups will be compared, group one consisting of 4 classes participating in special keyboard experiences and group two a control group. Tests of significance between the two groups will be computed on tonal memory, pitch discrimination, rhythmic discrimination, ability to read music, ability to detect errors in the score, ability to determine meter, ability to hear chords and cadences, ability to determine phrases and factual knowledge. Analysis of covariance will be used if significant differences are found in pretests.

The computer will be used to obtain mean, standard deviation, variance and t value for the several groups. If covariance is necessary, the computer will be used to obtain sums, sums of squares and cross products.

Cautions about intrasession history will be observed, and efforts to distinguish slope of learning pattern will be made by administering short classroom tests at three week intervals. It is anticipated that the computer will not be necessary for this phase. (R. J. Colwell)

1636-59003 Sociology. Small Groups and Self Concept. The problem under investigation and for which computer time is requested involves an examination of the question of how small group performance and small group structure affect the self concepts of the group participants. Data have been collected from two experiments to date. One experiment is of the laboratory type task discussion group in which the past academic performances of the subjects is controlled. The second is a "natural" experiment focusing upon the self-concept changes of speech students over an 8 week certification course.

The requested computer time will be used primarily for statistical analysis of these data. There may be some need for further ordering of the data on cards or tapes. For the presently planned analysis it appears that SSURAC programs CORRELATION, ANALYSIS OF VARIANCE, ARRAY and some selection of a factor analysis program will be adequate. (Gene F. Summers)

1637-59004 Theoretical and Applied Mechanics. Fatigue of Aircraft Metals. Calculations of longitudinal stress-strain hysteresis loop from the diametral strain and longitudinal stress data are as follows:

a) Hysteresis energy by Simpson's rule.

b) Determination of the cyclic hardening exponent n and cyclic strain hardening coefficient. The material constant n of the cyclic stress-strain relationship $\sigma = k(\epsilon_p)^n$ is calculated by numerical integration. Although the value n is usually determined by the method of least squares, it is calculated by the following relationship:

$$n = \frac{(\sigma_o * \epsilon_{p,o}) - \int^{\epsilon_{p,o}} \sigma \, d\epsilon_p}{\int^{\epsilon_{p,o}} \sigma \, d\epsilon_p}$$

c) True stress, true strain relationship.

d) Calculation of longitudinal strain from diametral deformation.

(Tatsuo Endo)

1638-59005 Law. Information Retrieval. The aim of this work is to study problems connected with the retrieval of pertinent documents by automatic searching with the 7094 computer. The raw data consists of natural language text representing abstracts of over 5,000 law cases. Given a specific law case, the goal of the retrieval program is to find those cases, out of the 5,000, which are pertinent to the case in hand. (I. J. Krakower)

1639-59006 Theoretical and Applied Mechanics. Fracture Toughness of Metals. The digital computer is used in the study of fracture toughness of metals in two ways. The first is the analysis of the data determined from laboratory work and the second is the determination of mathematical expressions to represent experimentally determined curves. This is done by numerical techniques such as the least square polynomial fit method. (W. Van Der Sluys)

1640-59007 Education. Occupational Characteristics Index Norming. The research task is to discover the ways in which individuals and groups of individuals solve the problems presented by the Occupational Characteristics Index. This Index includes 21 personality Characteristics (traits). Alternate sets of directions to the respondents ask that they use the Characteristics to describe Self-Actual, Self-Ideal, Peer-Actual, Peer-Ideal, Subordinate-Actual, Subordinate-Ideal, Administrative Superior-Actual, and/or Administrative Superior-Ideal.

The respondent is confronted with 21 sets of Characteristics (traits) each. He is to rank order (or weight) the traits in each set from one to five (one is highest and five is lowest.) When the task is complete the respondent has compared each of the traits once and only once with every other to obtain an overall rank order (or weight) for each trait.

The computer sums the weights the respondent has assigned to each of the traits. It also sums and averages the weights assigned to each cluster of traits. (A cluster is composed of positively correlated traits each of which is also negatively correlated with the traits in an opposing cluster.) The computer will also provide a factor score derived from each paired sets of opposing clusters. (Ray Simpson)

1641-59008 Chemistry and Chemical Engineering. Barriers to Rotation. The origin of the barrier to internal rotation in the ethane and related molecules has been the origin of a large number of investigations. These usually involve computing the energy of the molecule in the staggered and eclipsed configurations and subtracting to obtain the barrier. The present approach is to consider the molecule in a configuration intermediate between the staggered and eclipsed and compute the torque on one of the CH_3 tops. From this, together with simplifying assumptions about the shape of the barrier, the height of the barrier can be computed.

Calculation of the torque implies calculation of the forces on the nuclei due to other nuclei and the electrons. The nontrivial part of this calculation is the evaluation of a large number of two- and three-center integrals. These can be reduced to sums of one-dimensional integrals involving Bessel functions. These integrals are done numerically, employing a Simpson's Rule method taken from a library subroutine. (Jerry Goodisman)

1642-59012 T Physics. Nuclear Spin Cross Relaxation Times. The cross relaxation times between various nuclear spin systems in a metal will be studied. The computer will be used to calculate from nuclear resonance data the cross relaxation times as a function of the applied magnetic fields. These relaxation times will then be used to calculate nuclear resonance lineshapes. (Joe Pifer)

1643-59014 Department of Computer Science. Experiments in Numerical Analysis. The purpose of this work is to gather experimental evidence on the efficiency of certain new methods for the solution of nonlinear equations and for numerical integration. (J. Nievergelt)

1644-59015 Zoology. Analysis of Hybrid Pocket Gophers. Specimens of pocket gophers have been collected from a restricted area in southern Arizona for special study. It is believed that these specimens may represent, in part, hybrids between two species of the genus Thomomys. A BIMED 05 program is to be used to compute linear discriminant coefficients which will be used in an effort to distinguish between specimens of these two species and hybrids. (Hoffmeister)

1645-59016 T Educational Testing. Cognitive Similarity. Read and print from a table (including all permutations of 123456 (6 elements) and the corresponding values of collinearity, rho, and tau) the values corresponding to the observed I-scales (rank-orders) of 6 elements as obtained from subjects in a doctoral dissertation research project.

Tabulate frequencies of occurrences of different values of rho and tau at different levels of collinearity.

Tabulate frequencies of high and low grades under different levels of collinearity and/or values of tau. (Mohamed I. Youssef)

1646-59019 Horticulture. Mulch and Plant Growth. Computer will be used to solve analysis of variance and regression problems for various factors involved in herbicide work on vegetable crops. Several studies have been carried out this summer on several vegetable crop species and these studies will be analyzed on the computer. Several factors will be analyzed on a corn mulch study carried out at Urbana during the 1965 growing season. (Hopen)

1647-59020 Forestry. Red Oak-Cottonwood Strength Values. The problem involves a test of standard strength-ratio tables that predict the effect that such defects as knots and cross grain have on bending strength of wood beams. Predicted and actual strength ratios were obtained for 600 red oak and cottonwood beams. The beams, 2 x 4's and 2 x 8's, were loaded to failure over a 9-foot span. The computer analysis considered the correlation of actual values with predicted values and an analysis of variance. The main sources of variation were mill operator, species of wood, depth of beam, and type of manufacture. (C. S. Walters)

1648-59021 Education. Student Alienation in the College Community. This problem is concerned with faculty-student relations in the modern university. It focuses on the students' feelings of alienation from the university. The nature of the problem requires gathering large samples from several institutions. The computer is necessary to rapidly and accurately analyze these data. At the present time only standard library routines, chiefly correlational and factor analytic techniques are contemplated. (David C. Epperson)

1649-59023 T Sociology. Response Bias. This research problem will investigate certain aspects of data obtained by the Institute for Research on Exceptional Children of the University of Illinois. The data were obtained by their Project on Education of Deaf and Hard of Hearing Adults, and consists of the results of about a thousand interviews obtained by a mailed questionnaire.

This study will use the above data to investigate what response biases to a mailed questionnaire can be explained by the fact that a respondent is a member of a number of overlapping groups. It is theorized that the strength of affiliation to a number of overlapping groups will result in differences in response to a questionnaire, and will also result in differences when a mailed questionnaire is returned. Frequency counts will be used to find those individuals who are members of overlapping groups, and this data will be analyzed by use of "reference group strategy models" that have been developed. It is hoped that this investigation will lead to a theory concerning the reasons why an individual does not respond to a mailed questionnaire.

The computer is necessary for this investigation because of the large number of variables and interviews that frequency counts must be obtained from for analysis. Only by using a computer would it be possible to obtain the large number of frequency tables needed by this investigation in a reasonable time. (Frank Burke)

1650-59027 Chicago Circle, Architecture. Architecture Room Area Analysis. This project is an analysis of certain relationships between a number of people in a room. The computer is used to find areas by triangulation on a network of triangles formed using all people in the room as vertices. It then assigns and evaluates the areas according to sex, nearest neighbors, and number of people in the room. (Robert Adams)

1651-59028 T Mechanical Engineering. A Basic Study of Entrainment Mechanisms. The research problem deals with drops produced by the rupture of bubbles at a liquid-gas interface. In particular their sizes and electrical charges, as a function of bubble size, bubble lifetime, liquid composition, and liquid temperature, are of interest. The production of drops, intrinsic in the rupture of the bubble, results in the commonly undesirable addition of liquid to the rising vapor. Efficient removal of these drops depends upon a knowledge of the items listed above.

At present, the anticipated computer usage lies in two areas: data reduction and theoretical analysis. The data reduction program involves use of some two hundred variable or fixed parameters for the purpose of determining bounded values of the quantities of interest. Iterative and plotting routines are to be used.

Since the theoretical analysis is not yet completed it is impossible to state precisely what will be done in this connection. If no satisfactory analytical expression can be derived, numerical methods will be applied to the governing partial differential equations. (Robert Medrow)

1652-59029 Physics. Regge Polology Etc. The work being done is elementary particle phenomenology. The desire is to explore energy dependence of various elementary particle cross sections with the aid of a least square fitting procedure and other numerical analyses of data. (Logan)

1653-59037 Department of Computer Science. Anharmonic Oscillator. These calculations will be used to study the equilibrium behavior of anharmonic oscillators. Some of these calculations will involve the numerical evaluation of Wiener integrals using Monte Carlo techniques. (Pete Stuckey)

1654-59038 Institute for Research on Exceptional Children. Classroom Interaction. The purpose of this study is:

1. To extend the previously developed Aschner-Gallagher classification system for classroom verbal interaction to include larger units of study--topics and themes which will provide a structure for analyzing mental operations in the classroom and a means to compare the relative outcomes of various teacher strategies.

2. To apply this expanded classification system to videotape and audiotape recordings of classroom interactions to determine whether different types of topics and teacher strategies stimulate different mental processes and different kinds of teacher-student interchange.

3. To relate classroom performance to variables of cognitive style, self-concept and sex.

Tests of divergent thinking abilities and attitude were administered to both teachers and students in the summer workshop. Videotape segments of teacher-student interaction of approximately 30 minutes duration were collected for each teacher. These videotapes were used as instructional devices within the workshop and preserved for further viewing by project staff. These observations will be first used to extend and develop a system of critical incidents.

The cognitive performance of students and teachers within each of the various types of topics will be compared. Analyses of student performance in the different topics will be differentiated by sex and cognitive style, both of which appeared to be significant variables in the previous study. The comparison method of choice will be analysis of variance or the 't' test, with such nonparametric methods or other techniques as seem appropriate. (James J. Gallagher)

1655-59030 Physics. Analysis of SMP Data. This problem specification replaces 3D022. (Mortara)

1656-59039 T Civil Engineering. Development of Indices Relating the Physical Properties and Engineering Behavior of Rock. The purpose of this research is the development of a classification system of rock in situ which will correlate the physical properties of rock with its engineering behavior. This particular effort will have its major emphasis on the application of appropriate reduction factors to be applied to corresponding properties of intact core specimens as investigated in the lab under a previous research program.

The computer will be used for basic data reduction and statistical analysis. (R. F. Coon)

1657-59040 T Department of Computer Science. Minimization of Thresholds. Minimize the number of thresholds required to realize a Boolean function by linear programming approach. (Y. T. Yen)

1658-59041 Civil Engineering. Mono Versus Stereo Analytical Photogrammetry. The project involves processing the raw data observed in the WILD STK-1 Stereocomparator and applying the method of least squares to arrive at the best estimates of a number of parameters involved in the comparison between the monocular and the steroscopic approaches to analytical photogrammetry. A statistical analysis of residual errors in both approaches will also be undertaken. (H. M. Karara)

1659-59042 Civil Engineering. Flexural Behavior of Prestressed Concrete Beams. During the past two years a general program has been developed in the Department of Civil Engineering for calculation of the load-deflection relationship for simply-supported prestressed concrete beams. The load-deflection relationship for prestressed concrete beams varies with the magnitude of the load and is nonlinear for high stages of loading. The program developed is based on a numerical method which calculates the deflection for any magnitude of load between zero and the collapse load.

It is intended to use this program to study the influence of each variable on the load-deflection property with the ultimate aim of developing serviceability criteria for design of prestressed concrete beams. (Khachaturian)

1660-59043 Agronomy. Instrument Calibration. Periodic calibration of optical spectrograph, X-ray, nuclear magnetic resonance, and other laboratory instruments is necessary. Normally, instrument readings are made for a set of standards with known composition and a regression line plot is constructed. This graph is then used to interpret subsequent instrument readings from samples of unknown composition.

A program has been developed to read in data from a set of standards, compute the best fitting regression line, and plot a graph of this line. Use of this program will greatly simplify the calibration problem, reduce the time involved, and also eliminate errors. (Carmer)

1661-59045 Physics. Intermediate Resonance. A differential cross section of proton, neutron, and α-particles scattered elastically from even-even mass nuclei is calculated by using an intermediate resonance formalism. A simultaneous search of spins, parities, resonance energies, total widths, partial widths, and relative phases of two intermediate resonances is to be done so as to obtain a best fit cross section by means of the least chi-squared method, feeding in experimental energy distribution and angular distribution data in arbitrary units or absolute value. A result of the optical model calculation for the averaged angular distribution data, such as reflection factors and coulomb factor, is requested as a part of input. (Izumo Ko)

1662-59047 Civil Engineering. Analytical Photogrammetry in Highway Location and Design. This project involves the treatment of the raw data extracted from the WILD STK-1 Stereocomparator. The problem involves the formation and adjustment of mathematical models of single models, strips, and blocks of strips by the method of least squares and a statistical analysis of the residual errors. (H. M. Karara)

1663-59048 I Mining, Metallurgy and Petroleum Engineering. Effect of Underground Stress Field on Surface Features. It is planned to solve complicated elasticity problems, such as notch-type examples. Integrals will be evaluated, equations generated, and solutions plotted. (John R. Sturgul)

1664-59054 Zoology. Numerical Taxonomy of Orthoptera. Statistical methods are to be used in an attempt to incorporate character analysis into the usual procedures of numerical taxonomy. The organisms used will be grasshoppers and the camel cricket Centhophilus guttulosus. (Eades)

1665-59058 Civil Engineering. Structure Shielding of Gamma Radiation. This project includes two problems in the shielding of gamma radiation by structures. These are:

a. The attenuation of radiation by finite slabs (e.g. floor slabs);
b. The effect of source anisotropy in free field measurements.

Limited experimental data on both these problems are available. Rigorous solution of exact equations governing the phenomena is beyond the limits of present knowledge. Approximate equations can, however, be written and these will be solved using the computer. The equations are differential equations giving the dose due to radiation incident on a differential volume of structure, or due to a differential area of source. These equations are integrated numerically over the space coordinates. (Preiss)

1666-59060 Psychology. Anxiety and Reinforcement. The project involves an experimental approach to the study of personality development, with a focus on anxiety in children and reinforcement effects with children. One series of studies deals with the relationships between test anxiety and defensiveness and a variety of intellective and personality variables, including creativity measures, standard tests of intelligence and achievement, indices of school progress, and measures of sex-typing, compulsivity, and sociometric status. A second series of studies focuses on the effects of social reinforcement and nonreinforcement from adults on the performance of children at simple tasks as a function of a number of pretraining experiences, subject variables, and experimenter variables.

Most of the present and planned studies involve correlational analyses, analyses of variance, and descriptive statistics which involve standard SSUPAC programs. (Kennedy Hill)

9.2 Instructional Problem Specifications

During the third quarter of 1965, 12 instructional problem specifications were submitted to the Department for computation. The following brief descriptions of these problems have been prepared for inclusion in this report by those submitting them.

I179-57010 Chemistry and Chemical Engineering 490. Chemistry Short Course in SCATRE. There will be two problems for the course. The first is a complete SCATRE program. The second will be a SCATRE subroutine with a FORTRAN or MAD main program. The subroutine will involve the use of the 7094 double precision instructions. (Don Secrest)

I183-57038 Electrical Engineering 343. Problem No. 5. This problem is concerned with the solution of a 6 node feedback amplifier circuit, which involves the solution of a 6 x 6 matrix with complex numbers. (J.H. Bruning)

I184-57043 Electrical Engineering 382. Network Analysis. It is desired to analyze several linear equivalent circuits for transistor amplifiers, using an existing program. (M. H. Crothers)

I185-57044 Graduate School of Business Administration 544. Petroleum Simulation. The program represents an extensive simulation of the physical and economic aspects of the petroleum industry which in turn serves as a decision-working laboratory for the graduate students.

Like most business games the primary objective of the exercise is the development of decision-making skills. The computer game is realistic and complex enough to add dimensions to business decision problems which are not possible or efficient in the classroom. (Richartz)

I186-57050 Civil Engineering 316. Problem No. 1. Linear Programming. Linear programming problems concerning construction engineering will be assigned throughout the semester and the students will set them up from problem descriptions. The linear programming option in SSUPAC will be used for the solution of the problems. Approximately ten separate problems will be assigned during the semester. (E. L. Murphree)

I188-58002 Anthropology 364. Multivariate Analysis of Field Data. This problem requires analysis by multiple regression and other multivariate techniques of data concerning samanotype and blood group genetics of a population studied. (J. Casagrande)

I190-58007 Marketing 321. Marketing Research on Lawn Care Behavior. This problem has been designed to determine the lawn-care activities of Champaign-Urbana households. With the data obtained from a sample using a pre-coded questionnaire, the computer can make computations to fix parameters for certain aspects of the problem. Later, some of the values for the parameters will be used in a written report. (H. G. Wales)

I196-59017 Aeronautical and Astronautical Engineering 216. Gas Dynamics. The machine will be used to generate answers to relatively complex gas dynamic problems so that the student may check the answers with hand calculation. It will also be used to prepare tabulations of gas dynamic properties useful for the student in problem solving. (R.A. Strehlow)

I198-59022 Aeronautical and Astronautical Engineering 241. Problem No. 1. Aerospace Vehicle Design. The computer will be used to aid in the design of an aerospace vehicle in the following ways:

1) Repetitious calculations which are required for comparison of various designs of vehicle and propulsion system components.
2) Long or difficult calculations such as rocket nozzle contour or propellant tank heat balance.
3) Mission analysis studies.
4) System optimization by formulating performance programs to represent an entire system.

(V. P. Roan)

I207-59036 Civil Engineering 497. Problem No. 1. Analytical and Numerical Aerotriangulation. The computer will be used to solve the equations associated with the mathematical models analytically constructed from the automatic readout system of a Wild STK-1 Stereocomparator. The equations will generally be solved by the method of least squares after three-dimensional orthogonal or three-dimensional unitary orthogonal transformations have been applied. (H. M. Karara)

I215-59055 Industrial Engineering 286. Problem No. 1. SSUPAC Linear Programming. Industrial Engineering 286 is a basic course in operations research. Linear programming is a part of the course. The students, after learning a manual method of solving an L.P. problem, will use SSUPAC to solve other problems assigned. (Lloyd Lehn)

I219-59061 Civil Engineering 391. Problem No. 1. Several short programming assignments will illustrate application of numerical, data-processing, and logical methods to civil engineering problems. In addition, graduate students will be writing individual term projects involving the development of an original program from inception to final debugging. (S. Fenves)

9.3 Blanket Class Problem Specifications

During the third quarter of 1965, 29 problem specifications were submitted to cover all assigned problems in the following courses:

J180-57014 Electrical Engineering 415.

J181-57019 Civil Engineering 391.

J182-57028 Graduate School of Business Administration 531.

J187-57067 Advertising 482.

J189-58004 Department of Computer Science 387.

J191-58029 Finance 454.

J194-59010 Electrical Engineering 331.

J193-59011 Electrical Engineering 451.

J195-59013 Nuclear Engineering 900.

J197-59018 Aeronautical and Astronautical Engineering 438.

J199-59024 Department of Computer Science 996.

J200-59025 Mathematics 149.

J201-59026 Mathematics 195.

J202-59031 Mechanical Engineering 214.

J203-59032 Mechanical Engineering 264.

J204-59033 Mechanical Engineering 263.

J205-59034 Mechanical Engineering 306.

J206-59035 Mechanical Engineering 215.

J208-59044 Agronomy 365.

J209-59046 Mechanical Engineering 260.

J210-59049 Chemistry and Chemical Engineering 490.

J211-59050 Aeronautical and Astronautical Engineering 426.

J212-59051 Chemistry and Chemical Engineering 341.

J213-59052 Industrial Engineering 350.

J214-59053 Electrical Engineering 322.

J216-59056 Electrical Engineering 428.

J217-59057 Electrical Engineering 296.

J218-59059 Electrical Engineering 323.

J220-59062 Civil Engineering 391.

Table I - IBM 1401-I

Summary of Use

July, 1965

Scheduled Engineering	1:30
Unscheduled Engineering	7:05
Maintenance	7:15
7094 Preparation	520:49
Listing	15:04
Code Check	10:54
Tape Duplication	:15
Tape Dump	13:57
Reproduction	13:42
SMP	37:15
Tape Testing	3:03
ILLIAC Preparation	6:21
Idle	14:45
Total	651:55

Table II - IBM 1401

Summary of Machine Errors

July, 1965

1402 Card Reader Punch	4
1403 Printer	3
729V Tape Drives	3
Total	10

Table I - IBM 1401-II

Summary of Use

July, 1965

Scheduled Engineering	2:52
Unscheduled Engineering	10:40
Maintenance	8:29
7094 Preparation	443:26
Listing	30:34
Code Check	21:57
Tape Duplication	3:03
Tape Dump	9:25
Reproduction	18:51
SMP	32:34
Tape Testing	3:29
Tape Label	1:33
ILLIAC Preparation	7:36
Idle	27:25
Total	621:54

Table II - IBM 1401

Summary of Machine Errors

July, 1965

1401 Main Frame	2
1402 Card Reader Punch	4
1403 Printer	5
729V Tape Drives	1
Total	12

Table I - IBM 7094

Summary of Use

July, 1965

Scheduled Engineering				25:39
Unscheduled Engineering				2:58
Maintenance				13:52
Air Conditioning				1:33
Idle				6:28
Miscellaneous (Operator training, tape rewind, tape mounting, both system and user, rerun of failing problems, tape skipping, destruction of clock reading)				55:35
Total Use				
Training and Education			20:24	
University Administrative Overhead Use			19:10	
System Updating			7:43	
System Modification and Improvement			48:25	
Customer Use:				
In System		329:15		
Relinquish				
AGEC	8:17			
ED	:14			
PHYCS	133:01			
		141:32		
Special Short Shots		:30		
			471:17	
Total Use				566:59
Total Time On				673:04

Table II - IBM 7094

Summary of Machine Errors

July, 1965

721 Card Punch	1
729V Tape Drive	7
7094 Air Conditioning System	2
7094 Undetermined Errors	1
Suspected Tape Errors	2
Total	13

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	TandE[2]	Res	Total	TandE[2]	Res	Total	TandE[2]	Res	Total
AAE	0	227	227	0	6	6	0.0	8 34.0	8 34.0
ADV	0	78	78	0	1	1	0.0	49.7	49.7
AGE	0	82	82	0	4	4	0.0	1 30.5	1 30.5
AGEC	0	289	289	0	22	22	0.0	13 38.6	13 38.6
AGREX	0	8	8	0	1	1	0.0	8.6	8.6
AGRON	0	112	112	0	18	18	0.0	3 53.6	3 53.6
ANGEN	0	6	6	0	1	1	0.0	1.4	1.4
ANS	0	129	129	0	4	4	0.0	1 58.5	1 58.5
ANTH	133	0	133	2	0	2	10 41.2	0.0	10 41.2
ASTR	0	122	122	0	3	3	0.0	1 34.9	1 34.9
BECBS	0	149	149	0	2	2	0.0	2 10.4	2 10.4
BEDRE	0	32	32	0	1	1	0.0	11.5	11.5
BOT	0	4	4	0	1	1	0.0	31.7	31.7
CE	276	1944	2220	2	44	46	1 57.7	46 6.1	48 3.8
CHE	93	1348	1441	1	49	50	25.6	37 9.1	37 34.7
CRC	0	4	4	0	1	1	0.0	1.6	1.6
CZR	0	4	4	0	1	1	0.0	0.7	0.7
DCS	30	119	149	1	7	8	42.9	2 43.3	3 26.3
DS	0	132	132	0	4	4	0.0	1 46.9	1 46.9
DUE	99	0	99	1	0	1	1 31.0	0.0	1 31.0
ECON	0	190	190	0	5	5	0.0	5 22.6	5 22.6
ED	0	119	119	0	7	7	0.0	7 20.8	7 20.8
EDADM	0	5	5	0	1	1	0.0	13.1	13.1
EDTES	0	2	2	0	1	1	0.0	17.5	17.5
EE	49	745	794	4	20	24	22.5	12 48.7	13 11.3
ENGLS	0	6	6	0	1	1	0.0	9.5	9.5
FIN	4	0	4	1	0	1	0.7	0.0	0.7
FOR	0	20	20	0	3	3	0.0	59.4	59.4
FT	0	32	32	0	2	2	0.0	10.3	10.3
GEOG	0	2	2	0	1	1	0.0	0.8	0.8
GEOL	0	2	2	0	1	1	0.0	0.6	0.6

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	TandE[2]	Res	Total	TandE[2]	Res	Total	TandE[2]	Res	Total
GSBA	45	0	45	3	0	3	35.0	0.0	35.0
HEC	0	6	6	0	1	1	0.0	3.5	3.5
HLTHS	0	2	2	0	1	1	0.0	32.3	32.3
HORT	0	16	16	0	2	2	0.0	20.3	20.3
ICR	0	67	67	0	4	4	0.0	2 18.1	2 18.1
IED	0	85	85	0	1	1	0.0	1 13.7	1 13.7
IGPA	0	19	19	0	2	2	0.0	14.5	14.5
INADM	0	12	12	0	1	1	0.0	15.9	15.9
IREC	0	29	29	0	4	4	0.0	1 6.2	1 6.2
LIBS	0	7	7	0	2	2	0.0	59.3	59.3
LIR	0	2	2	0	2	2	0.0	8.0	8.0
MATH	757	0	757	1	0	1	2 58.3	0.0	2 58.3
ME	72	473	545	5	20	25	25.0	14 4.7	14 29.8
MEDIC	0	5	5	0	1	1	0.0	2.2	2.2
MKTG	0	9	9	0	1	1	0.0	9.1	9.1
MMPE	0	185	185	0	5	5	0.0	2 52.8	2 52.8
MUSIC	0	45	45	0	2	2	0.0	1 5.6	1 5.6
NHS	0	9	9	0	1	1	0.0	4.0	4.0
NUCE	48	338	386	1	12	13	40.3	5 15.6	5 56.0
OIR	0	341	341	0	2	2	0.0	14 14.8	14 14.8
PEM	0	24	24	0	5	5	0.0	1 3.9	1 3.9
PHYCS	2	2660	2662	1	32	33	0.2	220 50.2	220 50.5
POLS	2	23	23	1	2	3	0.6	43.5	44.2
PSYCH	0	827	827	0	30	30	0.0	27 2.1	27 2.1
PSYTR	0	3	3	0	1	1	0.0	41.5	41.5
REC	0	39	39	0	1	1	0.0	1 10.6	1 10.6
SCONS	0	38	38	0	2	2	0.0	2 14.2	2 14.2
SCS	0	6	6	0	2	2	0.0	17.3	17.3
SOC	0	24	24	0	2	2	0.0	23.6	23.6
SPCH	0	3	3	0	1	1	0.0	7.7	7.7

Dept[1]	Number of Runs TandE[2]	Res	Total	Number of Specs TandE[2]	Res	Total	7094 Usage in Hours-Minutes TandE[2]	Res	Total
SWS	0	158	158	0	13	13	0.0	2 55.3	2 55.3
TAM	2	272	274	1	8	9	2.9	7 28.4	7 31.4
UNIHI	0	128	128	0	2	2	0.0	6 16.4	6 16.4
VMS	0	10	10	0	1	1	0.0	12.0	12.0
VPH	0	38	38	0	3	3	0.0	35.7	35.7
XSSS[3]	0	89	89	0	1	1	0.0	30.1	30.1
ZOOL	0	59	59	0	5	5	0.0	3 25.4	3 25.4
Subtotal	1612	11963	13575	25	387	412	20 24.6	487 31.8	507 56.5
DCSSY[4]	0	1469	1469	0	19	19	0.0	48 24.7	48 24.7
XDCS[5]	0	70	70	0	1	1	0.0	7 42.8	7 42.8
SSUAD[6]	0	665	665	0	2	2	0.0	2 55.3	2 55.3
Total	1612	14167	15779	25	409	434	20 24.6	546 34.6	566 59.3

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Improvement and Modifications
5 System Updating
6 University Administrative Overhead Use

Table I - IBM 1401-I

Summary of Use

August, 1965

Scheduled Engineering	2:28
Unscheduled Engineering	9:10
Maintenance	6:29
7094 Preparation	523:50
Listing	17:53
Code Check	18:44
Tape Duplication	:15
Tape Dump	15:25
Reproduction	11:50
SMP	37:15
Tape Testing	6:27
Tape Label	:31
ILLIAC Preparation	1:17
Idle	15:24
Total	666:58

Table II - IBM 1401-I

Summary of Machine Errors

August, 1965

1401 Main Frame	0
1402 Card Reader Punch	4
1403 Printer	5
1406 Core Storage	0
729 V Tape Drives	4
Total	13

Table I - IBM 1401-II

Summary of Use

August, 1965

Scheduled Engineering	2:48
Unscheduled Engineering	6:15
Maintenance	7:30
7094 Preparation	470:40
Listing	19:10
Code Check	33:45
Tape Duplication	1:25
Tape Dump	8:37
Reproduction	24:22
SMP	25:50
Tape Testing	2:01
Tape Label	4:43
ILLIAC Preparation	3:20
Idle	47:53
Total	658:19

Table II - IBM 1401-II

Summary of Machine Errors

August, 1965

1402 Card Reader Punch	4
1403 Printer	5
729 V Tape Drives	1
Total	10

Table I - IBM 7094

Summary of Use

August, 1965

Scheduled Engineering			47:00
Unscheduled Engineering			9:14
Machine Maintenance			10:27
Idle			3:24
Miscellaneous (Operator training, tape rewind, tape mounting, both system and user, rerun of failing problems, tape skipping, destruction of clock reading)			51:59
Total Use			
Training and Education		9:15	
University Administrating Overhead Use		13:30	
System Modification and Improvement		59:34	
System Updating		11:28	
Customer Use			
In System		317:43	
Relinquish			
AGEC	5:36		
FOR	:16		
PHYCS	122:27	128:19	
Special Short Shots		:21	
		446:23	
	Total Use		540:10
	Total Time On		662:14

Table II - IBM 7094

Summary of Machine Errors

August, 1965

716 On Line Printer		1
729VI Tape Drive		4
7094 Operators Console		1
7094 Air Conditioning System		1
7094 Undetermined Errors		3
Suspected Tape Errors		1
7302 Core Storage		1
	Total	12

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
AAE	0	99	99	0	4	4	0.0	2 17.6	2 17.6
ADV	2	41	43	1	1	2	6.8	44.1	51.0
AGE	0	46	46	0	3	3	0.0	40.2	40.2
AGEC	0	370	370	0	21	21	0.0	13 28.3	13 28.3
AGREX	0	2	2	0	1	1	0.0	3.4	3.4
AGRON	0	275	275	0	19	19	0.0	12 57.5	12 57.5
ANGEN	0	6	6	0	1	1	0.0	1.4	1.4
ANS	0	73	73	0	4	4	0.0	2 23.0	2 23.0
ANTH	13	0	13	1	0	1	32.8	0.0	32.8
ASTR	0	110	110	0	3	3	0.0	1 16.8	1 16.8
BECBS	0	101	101	0	2	2	0.0	2 15.8	2 15.8
BEDRE	0	32	32	0	1	1	0.0	11.1	11.1
BOT	0	1	1	0	1	1	0.0	3.9	3.9
CE	391	1781	2172	3	46	49	4 2.3	47 5.8	51 8.2
CHE	11	1533	1544	1	48	49	4.6	39 29.9	39 34.6
CRC	0	32	32	0	1	1	0.0	28.6	28.6
CZR	0	3	3	0	1	1	0.0	1.0	1.0
DCS	21	71	92	1	4	5	21.0	1 45.4	2 6.4
DS	0	203	203	0	4	4	0.0	2 45.8	2 45.8
DUE	1	0	1	1	0	1	0.5	0.0	0.5
ECON	0	171	171	0	9	9	0.0	4 43.3	4 43.3
ED	0	15	15	0	5	5	0.0	16.3	16.3
EDPSY	0	2	2	0	1	1	0.0	4.6	4.6
EDTES	0	131	131	0	1	1	0.0	1 29.6	1 29.6
EE	42	534	576	3	17	20	35.8	13 44.2	14 20.1
ENGLS	0	37	37	0	1	1	0.0	47.4	47.4
FIN	20	0	20	1	0	1	6.4	0.0	6.4
FOR	0	20	20	0	4	4	0.0	39.4	39.4
FT	0	25	25	0	2	2	0.0	7.6	7.6
GEOG	0	1	1	0	1	1	0.0	0.9	0.9
GSBA	167	0	167	2	0	2	1 49.4	0.0	1 49.4
HEC	0	9	9	0	1	1	0.0	7.5	7.5
HLTHS	0	6	6	0	2	2	0.0	1 50.1	1 50.1
HORT	0	3	3	0	1	1	0.0	1.2	1.2

7094 Table III August 1965 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	TandE[2]	Res	Total	TandE[2]	Res	Total	TandE[2]	Res	Total
ICR	0	37	37	0	4	4	0.0	1 58.4	1 58.4
IED	0	56	56	0	2	2	0.0	29.3	29.3
IGPA	0	20	20	0	2	2	0.0	10.0	10.0
ILR	0	5	5	0	1	1	0.0	1.0	1.0
INADM	0	21	21	0	1	1	0.0	16.5	16.5
IREC	0	23	23	0	3	3	0.0	19.9	19.9
LIBS	0	3	3	0	1	1	0.0	1.0	1.0
LIR	0	4	4	0	1	1	0.0	10.6	10.6
MATH	99	8	107	1	1	2	22.8	1.9	24.7
MCBIO	0	4	4	0	1	1	0.0	9.5	9.5
ME	33	320	353	4	17	21	29.3	9 53.2	10 22.6
MEDIC	0	9	9	0	1	1	0.0	7.1	7.1
MKTG	1	0	1	1	0	1	1.2	0.0	1.2
MMPE	0	81	81	0	4	4	0.0	2 21.5	2 21.5
MUSIC	0	47	47	0	2	2	0.0	1 8.8	1 8.8
NHS	0	8	8	0	1	1	0.0	2.1	2.1
NUCE	1	251	252	1	9	10	0.1	3 45.6	3 45.8
OIR	0	161	161	0	3	3	0.0	6 42.5	6 42.5
PEM	0	21	21	0	5	5	0.0	23.1	23.1
PHYCS	2	2753	2755	1	34	35	0.4	216 27.1	216 27.5
POLS	6	44	50	1	3	4	39.8	47.3	1 27.2
PSYCH	0	714	714	0	30	30	0.0	25 40.0	25 40.0
PSYTR	0	1	1	0	1	1	0.0	8.2	8.2
REC	0	5	5	0	1	1	0.0	10.7	10.7
SCONS	0	28	28	0	1	1	0.0	29.8	29.8
SCS	0	36	36	0	2	2	0.0	2 28.7	2 28.7
SOC	0	24	24	0	4	4	0.0	37.3	37.3
SOCW	0	2	2	0	1	1	0.0	2.1	2.1
SPCH	0	1	1	0	1	1	0.0	0.4	0.4
SRL	0	8	8	0	1	1	0.0	2.9	2.9
SWS	0	243	243	0	12	12	0.0	5 11.8	5 11.8
TAM	4	194	198	1	8	9	1.0	4 25.7	4 26.8
UNIHI	0	151	151	0	3	3	0.0	6 0.7	6 0.7
VMS	0	34	34	0	1	1	0.0	20.2	20.2
VPH	0	38	38	0	2	2	0.0	39.2	39.2

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	TandE[2]	Res	Total	TandE[2]	Res	Total	TandE[2]	Res	Total
VTED	0	8	8	0	1	1	0.0	22.4	22.4
XSSS[3]	0	59	59	0	1	1	0.0	21.3	21.3
ZOOL	0	47	47	0	3	3	0.0	2 8.4	2 8.4
Subtotal	814	11202	12016	24	379	403	9 15.2	446 22.1	455 37.4
DCSSY[4]	0	1435	1435	0	18	18	0.0	59 34.4	59 34.4
XDCS[5]	0	95	95	0	1	1	0.0	11 28.6	11 28.6
SSUAD[6]	0	368	368	0	2	2	0.0	13 29.6	13 29.6
Total	814	13100	13914	24	400	424	9 15.2	530 54.7	540 10.0

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Improvement and Modifications
5 System Updating
6 University Administrative Overhead Use

Table I - IBM 1401-I

Summary of Use

September, 1965

Scheduled Engineering	11:15
Unscheduled Engineering	28:56
Maintenance	8:19
7094 Preparation	414:33
Listing	12:38
Code Check	26:30
Tape Duplication	1:31
Tape Dump	7:30
Reproduction	11:54
SMP	30:21
ILLIAC Preparation	1:20
Idle	25:16
Total	580:03

Table II - IBM 1401-I

Summary of Machine Errors

September, 1965

1401 Main Frame	6
1402 Card Reader Punch	4
1403 Printer	4
729 V Tape Drives	2
Total	16

Table I - IBM 1401-II

Summary of Use

September, 1965

Unscheduled Engineering	65:17
Maintenance	10:47
7094 Preparation	365:16
Listing	17:05
Code Check	6:30
Tape Duplication	2:50
Tape Dump	13:56
Reproduction	13:13
SMP	22:18
Tape Testing	2:45
ILLIAC Preparation	2:47
Idle	33:48
Total	556:32

Table II - IBM 1401-II

Summary of Machine Errors

September, 1965

1401 Main Frame	9
1402 Card Reader Punch	6
1403 Printer	1
1406 Core Storage	1
729 V Tape Drives	5
Total	22

Table I - IBM 7094

Summary of Use

September, 1965

Scheduled Engineering			56:55
Unscheduled Engineering			5:38
Maintenance			9:41
Idle			40:57
Miscellaneous (Operating training, tape rewind, both system and user, rerun of failing problems, tape skipping, destruction of clock reading)			32:54
Total Use			
Training and Education		1:38	
University Administrative Overhead Use		17:11	
System Modification and Improvement		35:44	
System Updating		5:31	
Customer Use:			
In System	268:13		
Relinquish:			
AGEC	5:53		
PHYCS	93:50		
	99:43		
Special Short Shots	:22		
	368:18		
Total Use			428:22
Total Time On			574:27

Table II - IBM 7094

Summary of Machine Errors

September, 1965

711 Card Reader	1
716 Printer	1
729 VI Tape Drive	5
7094 Undetermined Errors	3
Suspected Bad Tape	1
Total	11

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
AAE	19	101	120	3	6	9	7.8	3 24.4	3 32.2
ADV	0	74	74	0	1	1	0.0	1 28.9	1 28.9
AGE	0	10	10	0	2	2	0.0	18.2	18.2
AGEC	0	146	146	0	16	16	0.0	7 46.2	7 46.2
AGRON	0	252	252	0	20	20	0.0	8 17.5	8 17.5
ANGEN	0	14	14	0	1	1	0.0	28.5	28.5
ANS	0	83	83	0	4	4	0.0	2 32.9	2 32.9
ASTR	0	74	74	0	3	3	0.0	42.7	42.7
BECBS	0	69	69	0	1	1	0.0	1 5.1	1 5.1
CCARC	0	6	6	0	1	1	0.0	3.2	3.2
CE	14	1256	1270	1	41	42	2.5	74 29.5	74 32.0
CHE	0	1183	1183	0	41	41	0.0	32 45.5	32 45.5
CRC	0	1	1	0	1	1	0.0	1.0	1.0
CZR	0	3	3	0	1	1	0.0	4.3	4.3
DCS	13	58	71	2	5	7	2.0	2 32.2	2 34.2
DGS	0	5	5	0	1	1	0.0	5.5	5.5
DS	0	168	168	0	3	3	0.0	2 28.1	2 28.1
ECON	0	10	10	0	4	4	0.0	14.5	14.5
ED	0	27	27	0	2	2	0.0	47.6	47.6
EDPSY	0	6	6	0	1	1	0.0	0.3	0.3
EDTES	0	11	11	0	2	2	0.0	9.0	9.0
EE	0	362	362	0	11	11	0.0	7 55.4	7 55.4
ENGLS	0	15	15	0	1	1	0.0	24.0	24.0
FIN	25	0	25	2	0	2	10.4	0.0	10.4
FOR	0	3	3	0	1	1	0.0	20.7	20.7
FT	0	8	8	0	1	1	0.0	1.7	1.7
GSBA	30	0	30	2	0	2	38.7	0.0	38.7
HEC	0	5	5	0	1	1	0.0	36.9	36.9
HLTHS	0	4	4	0	1	1	0.0	2 11.3	2 11.3
HORT	0	9	9	0	1	1	0.0	4.4	4.4

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
ICR	0	82	82	0	4	4	0.0	4 25.7	4 25.7
IGPA	0	37	37	0	2	2	0.0	22.6	22.6
ILR	0	1	1	0	1	1	0.0	0.4	0.4
INADM	0	20	20	0	1	1	0.0	7.7	7.7
IREC	0	7	7	0	2	2	0.0	4.0	4.0
LIR	0	15	15	0	1	1	0.0	7.3	7.3
MATH	93	14	107	2	2	4	22.1	7.2	29.4
MCBIO	0	6	6	0	1	1	0.0	14.3	14.3
ME	51	134	185	4	13	17	13.8	2 49.0	3 2.9
MEDIC	0	21	21	0	1	1	0.0	34.1	34.1
MMPE	0	44	44	0	2	2	0.0	1 0.4	1 0.4
MUSIC	0	8	8	0	1	1	0.0	4.8	4.8
NHS	0	36	36	0	4	4	0.0	40.9	40.9
NUCE	0	111	111	0	9	9	0.0	59.3	59.3
OIR	0	229	229	0	1	1	0.0	3 42.6	3 42.6
PEM	0	2	2	0	1	1	0.0	4.9	4.9
PHYCS	0	2372	2372	0	38	38	0.0	178 4.3	178 4.3
PSYCH	0	404	404	0	19	19	0.0	11 17.0	11 17.0
SCONS	0	47	47	0	1	1	0.0	1 23.8	1 23.8
SCS	0	23	23	0	2	2	0.0	34.3	34.3
SGS	0	9	9	0	1	1	0.0	1.6	1.6
SOC	0	32	32	0	3	3	0.0	48.3	48.3
SRL	0	12	12	0	1	1	0.0	15.6	15.6
SWS	0	193	193	0	11	11	0.0	4 35.1	4 35.1
TAM	0	131	131	0	8	8	0.0	1 58.4	1 58.4
UNIHI	0	42	42	0	2	2	0.0	56.6	56.6
VMS	0	22	22	0	1	1	0.0	5.6	5.6
VPH	0	5	5	0	1	1	0.0	3.0	3.0
VTED	0	13	13	0	1	1	0.0	7.6	7.6
WPGU	0	3	3	0	1	1	0.0	2.5	2.5

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
XSSS[3]	0	86	86	0	1	1	0.0	21.8	21.8
ZOOL	0	15	15	0	5	5	0.0	54.8	54.8
Subtotal	245	8139	8384	16	316	332	1 37.7	368 18.4	369 56.2
DCSSY[4]	0	785	785	0	18	18	0.0	35 43.9	35 43.9
XDCS[5]	0	77	77	0	1	1	0.0	5 31.1	5 31.1
SSUAD[6]	0	445	445	0	2	2	0.0	17 10.9	17 10.9
Total	245	9446	9691	16	337	353	1 37.7	426 44.3	428 22.1

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Improvement and Modifications
5 System Updating
6 University Administrative Overhead Use

10. GENERAL LABORATORY INFORMATION

10.1 Bibliography

During the quarter, the following publications were issued by the Laboratory

File Numbers

[1] Bayer, R., "Series-Parallel Decomposition of Sequential Machines," File No. 677, August 16, 1965.

[2] Brearley, H. C., "The Head Retraction of the Flying Head Drum," File No. 676, July 20, 1965.

[3] Hassler, E. B., "Comments on Quiktran," File No. 680-01, August 30, 1965.

[4] Hassler, E. B., "Comparative Costs of Remote Consoles," File No. 680-03, September 21, 1965.

[5] Hassler, E. B., "Observations of Remote Console and Time Sharing Systems," File No. 680-00, August 30, 1965.

[6] Levin, M. S., "OHM--Open House Monitor: Operating Instructions," File No. 679, September 3, 1965.

[7] Prendergast, L. A., and K. C. Smith, "ILLIAC III Circuit Book Notes,"

File No. 650-Add. 1, "NAND/NOR Logic Circuits," July 19, 1965
File No. 650-Add. 2, "Logic Loading and the DOT OR Connection," July 8, 1965
File No. 650-Add. 3, "Isometric and Other Tests for Circuit Boards," August 5, 1965
File No. 650-Add. 4, "Effect of Base Overdrive in the NOR or AND-NOR Configurations," August 6, 1965
File No. 650-183, "Wiring of Racks for Compatibility with 1018-214," July 6, 1965
File No. 650-183-00, "Logic Application," August 4, 1965
File No. 650-214, "Wiring of Racks Using 183 Cards for Replacement by 214," July 7, 1965
File No. 650-214-01, "Logic Application," August 4, 1965
File No. 650-235, "Shifted Threshold Gate Driver," July 12, 1965.

[8] Smith, J. J., "Basic," File No. 680-02, August 30, 1965.

[9] Toda, I., "Linear Sum Logic," File No. 678, September 1, 1965.

[10] Waters, J., "A Survey of Some Numerical Integration Methods Suitable for Nonlinear Coupled Oscillator Systems," File No. 675, August 25, 1965.

Report Numbers

[11] Bond, W. D., K. Ibuki, B. H. McCormick, R. E. Wiegel and J. A. Wilbur, "Preliminary Programming Manual for the ILLIAC III," (Not available), Report No. 185, July 7, 1965.

[12] Fosdick, L. D., and H. F. Jordan, "Path Integral Calculation of the Two-Particle Slater Sum for He_4," Report No. 186, August 20, 1965.

Theses

[13] Casasent, D. P., "Graphical Processing Using Hybrid Analog-Digital Circuitry," (M.S.), Report No. 187, August 30, 1965.

[14] Nievergelt, J., "Partially Ordered Classes of Finite Automata," (Ph.D.), Report No. 189, September 30, 1965.

[15] Prozeller, E. F., "Hybrid Circuits for the Paramatrix System," (M.S.), Report No. 188, September 7, 1965.

[16] Shao, T. S., "Numerical Solution of Plane Viscous Shock Reflections," (Ph.D.), Report No. 190, September 30, 1965.

10.2 Colloquium

"On Certain Classes of Finite Automata," by Professor Jurg Nievergelt, Research Assistant Professor of Mathematics, Department of Computer Science, University of Illinois, Urbana, Illinois, September 27, 1965.

10.3 Drafting

During the quarter, a total of 329 drawings were processed by both drafting sections.

	General and ILLIAC II	Pattern Recognition
Large Drawings	14	2
Medium Drawings	1	94
Small Drawings	0	3
Report Drawings (Task 15)	28	0
Report Drawings (1018)	0	25
ILLIAC II Service	22	0
Departmental Thesis	9	0
Thesis (Task 15)	30	0
Change Orders	11	48
Miscellaneous	15	0
File Numbers	0	04
Layouts	0	23
TOTAL	130	199

(K. Law, L. Prendergast)

10.4 Library

The Computer Science Library began with a few books on a shelf in the Engineering Research Laboratory. When the Digital Computer Laboratory was built, the library was moved to the basement there, and finally in the fall of 1961, it was moved upstairs to the second floor where it is now.

The library has grown from a few books to a few hundred and from one shelf to various sections, including: reference books, general books, proceedings, current and bound periodicals, pamphlets, IBM publications, Department of Computer Science publications, and a few restricted files. The most expensive publication in the library is the Auerbach Standard EDP Reports which collates all essential aspects of the EDP systems commercially available in the United States. Library services include the obtaining of pamphlets, reprints, and IBM manuals.

The size of the library at this time may be shown by the following figures (rounded off to the nearest 10):

General Books*	Reference Books	Proceedings
600	200	160

Number of Periodicals currently being subscribed to:	Number of bound periodical volumes
100	330

Presently, the books in the general book section are arranged according to author. The Library Committee, headed by Professor S. Muroga, decided that some classification scheme should be used instead, so they looked into the Dewey Decimal Classification and the Library of Congress Classification schemes. Both were found to be inadequate for books concerning computer, so the Computing Reviews scheme was adopted (with the addition of a few classification numbers). Computing Reviews, a periodical, has a rather extensive classification for its subject headings; there are main categories, subcategories, and finally categories under many subcategories. This scheme is printed in each bimonthly issue of Computing Reviews. The Library of Congress scheme is used for "other" books such as foreign language texts and books that concern the fields of mathematics, physics, and electrical engineering more than the computer field.

The card catalogue and the books should be rearranged and ready for use by the end of October.

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* The average number of books ordered per month (since the budget increase in January, 1965) is about 30.

10.5 Personnel

The number of people associated with the Laboratory in various capacities is given in the following table:

	Full-time	Part-time	Full-time Equivalent
Faculty	15	1	15.5
Visiting Faculty	3	2	4.0
Graduate Research Assistants	9	59	38.75
Graduate Teaching Assistants	0	1	.5
Professional Personnel	7	2	8.5
Administrative and Clerical	15	1	15.5
Other Nonacademic Personnel	55	103	100.0
TOTAL	104	169	182.75

The Computer Advisory Committee consists of Professor J. R. Pasta, Head of the Department; Professor J. N. Snyder, Associate Head of the Department; Professors L. D. Fosdick, H. G. Friedman, C. W. Gear, D. B. Gillies, N. T. Hamilton, D. J. Kuck, B. H. McCormick, S. Muroga, T. A. Murrell, J Nievergelt, W. J. Poppelbaum, S. R. Ray, J. E. Robertson and D. E. Slotnick.

10.6 Shops' Production

Job orders processed and completed during the third quarter of 1965, are as follows:

Facility	AEC 1018	AEC 1469
Machine Shop	47	37
Electronics Shop	51	76
Etch Shop	71	38
Layout Shop	47	22

Wiring of 611 standard printed circuit boards and 2,510 baby boards during this period accounted for 47,840 diodes and 15,831 transistors.

0.84
l6t
-1018-1076

Physics

COO-1018-1076
COO-1469-0017

VERTICAL FILE

QUARTERLY TECHNICAL PROGRESS REPORT

October, November, December 1965

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QUARTERLY TECHNICAL PROGRESS REPORT

October, November, December 1965

Department of Computer Science
University of Illinois
Urbana, Illinois

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1. CIRCUIT RESEARCH PROGRAM

(Supported in part by the Office of Naval Research Under Contract Nonr-1834(15).)

Summary

The first phase of the Paramatrix System has been completed by Edward Carr and David Casasent. Their efforts have since been concentrated on improving the System's operation.

In the Electro-Optical Work Dick Koo is investigating the possibilities of direct optical logic and has proposed "circuits" for the logical operations of NOT, OR and NAND. Steven Whiteside has used the optical differential amplifier to measure the diffraction pattern of a ruby laser.

Further researches by Chushin Afuso in Random Sequence Coding have led to the designs of a multiplier, divider and adder/subtracter for random pulse sequences.

In Tunneling Theory Michael Faiman has been investigating the nature of non-equilibrium distribution functions of electrons and holes.

Equipment for preliminary experiments on Photochromic Storage has been designed by Joseph Smith, who also discusses the selection of light sources and filters and summarizes some of the literature on the subject.

1.01 Paramatrix System

1.01.02 Noise Reduction

The first phase of the Paramatrix System is finished and attention has since been given to improving the definition of the display by reducing the noise in certain parts of the system, viz: power supplies, sensitivity voltage controls for the Comparator circuits, translation voltage controls for the Transformer, and Transformer resistor chain.

A ramp type ripple of about $\pm$20 mV on the power supply busses was found to be caused by poor location of the power supply sense wires. By replacing these with tinned copper braid (equivalent to 10g. wire), connected direct to the busses, the ripple was reduced to about $\pm$5 mV.

The sensitivity of all 32 Comparator circuits in the Interpolator is controlled by a single circuit described in the last Quarterly Technical Progress Report (July-September 1965, 1.01.03.4, Figure 3, p. 5). Variations in the output voltage of this circuit, caused by varying load current needs, were considerably reduced by connecting a capacitor between the base of the 2N1485 transistor and the +10 volt supply, which is the reference supply for the Comparator circuits.

A similar modification was made to the translation control circuits, which effect the horizontal and vertical movement of the display. It is important that the noise in these circuits be minimal, since they are connected to the inputs of high gain voltage amplifiers.

Capacitors have also been connected at alternate points along the resistor chains in the Tranformer. These have reduced the voltage variations, caused by successive switching of the Diamond circuits attached to the chains, from about ± 25 mV to less than ± 5 mV in the worst case.

1.01.03.1 Control Timing

A feature of the Paramatrix control circuitry is that the 64 digital signals, gX_i and gY_j ($i, j = 0, 1, \ldots, 31$), which step the Transformer through successive analog voltage states, are also used to digitize the output (i.e. light the display lamps in this first phase of Paramatrix). Obviously this digitization must be inhibited until the output of the Coincidence Unit is reliable - the interval of about 0.5μs required for generation of the analog voltages, tranformation, blur thinning and comparison with the input picture. The simple expedient that has been resorted to in order to obtain the necessary delay is to change the Paramatrix timing circuitry into a two-phase system by inserting a single scale-of-two counter (D.C.S. File No. 656) between the Paramatrix Clock and the Y-Counter. The result is that in the first phase of a given clock period the subsystem of Transformer, Interpolator and Coincidence Unit is activated; and in the second phase the output is digitized (display lamp is lit, or not, according to the state of the Coincidence Unit).

1.01.03.2 Out-of-Range Indicator

The transformer generates voltages, x_{ij} and y_{ij}, given by:

$$x_{ij} = \frac{1}{m} (X_i \cos\theta - Y_j \sin\theta) - a$$

$$y_{ij} = \frac{1}{n} (X_i \sin\theta + Y_j \cos\theta) - b$$

for the allowable range of $-7.5 \leq X_i, Y_j, x_{ij}, y_{ij} \leq +8$ volts. Even if X_i and Y_j are in range, there is an infinitude of values of a, b, m, n and θ that would put x_{ij} or y_{ij} or both out of range. (In practice, the Paramatrix circuitry does not allow analog voltages to exceed 10 volts in absolute magnitude.)
In order to prevent the Coincidence Unit from registering agreement between two out of range voltages, an "Out of Range Indicator" has been inserted, as shown in Figure 1. This circuit is a modified Comparator whose (digital) output is '1' if its "analog" input is either less than -7.5 volts or more than +8 volts. The figure also shows the addition of the second phase of timing which was described in section 1.01.03.1.

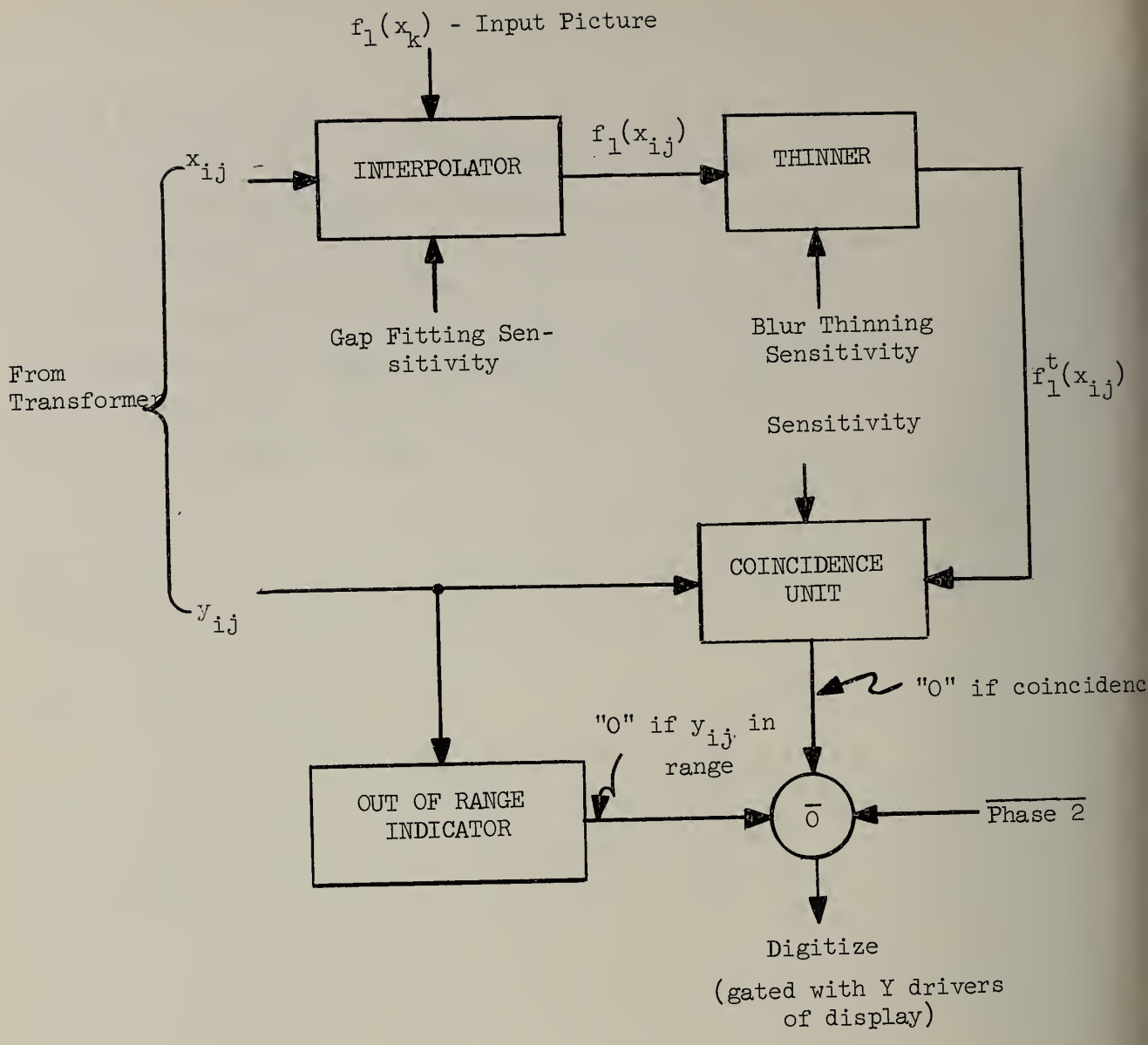


Figure 1. Addition of Modifications Described in 1.01.03.

1.02 Electro-Optical Work

1.02.07 Optical Logic

1.02.07.1 Wave Interference

A method of performing optical logic on monochromatic, coherent light beams is suggested and based on the principles of wave interference. The relative phase between two such beams is to be controlled by an Anderson diode placed in the path of one of the beams.

Two plane waves propagating in the same direction and having the same frequency, but with arbitrary amplitudes and phases, may be represented as vectors (Figure 1) and their resultant obtained by vector addition.

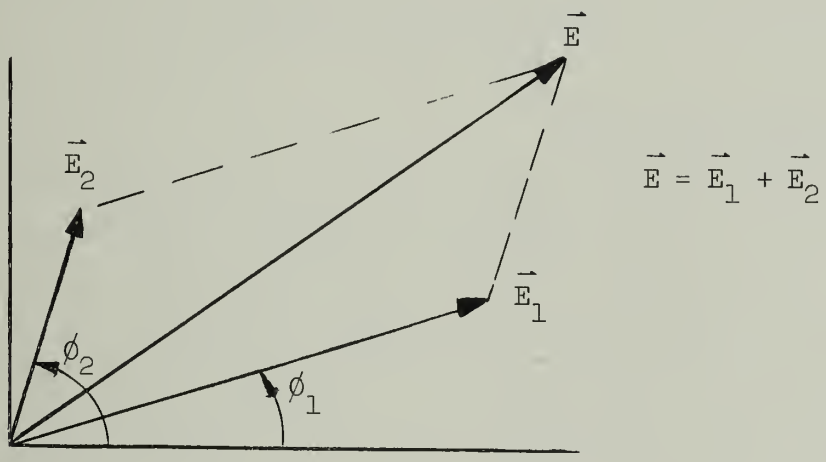


Figure 1. Vector Addition of Plane Waves.

Assuming that a monochromatic, coherent light beam may be represented by a plane wave, then, two such beams can be superposed by means of the beam splitter arrangement of Figure 2.

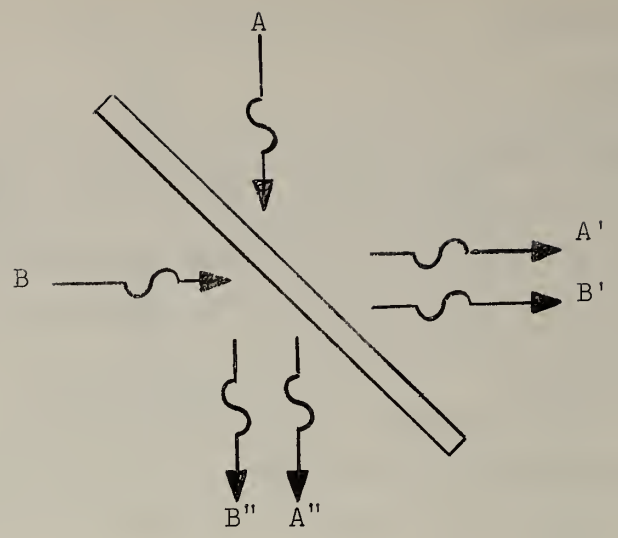


Figure 2. Beam Splitter.

1.02.07.2 Optical NOT Circuit

Figure 3a shows an Anderson diode and beam splitter arranged as an inverter. R is a reference beam (on continually) whose phase, on emerging from the diode, is some function of the reverse bias V. Beam A is the digital input (either on or off) and the amplitudes of R and A are so chosen that the amplitudes of A' and R' are equal. V is adjusted until A' and R' are 180° out of phase, so that destructive interference results. Then the vector diagram of Figure 3b shows how the output is present when A is absent and vice versa.

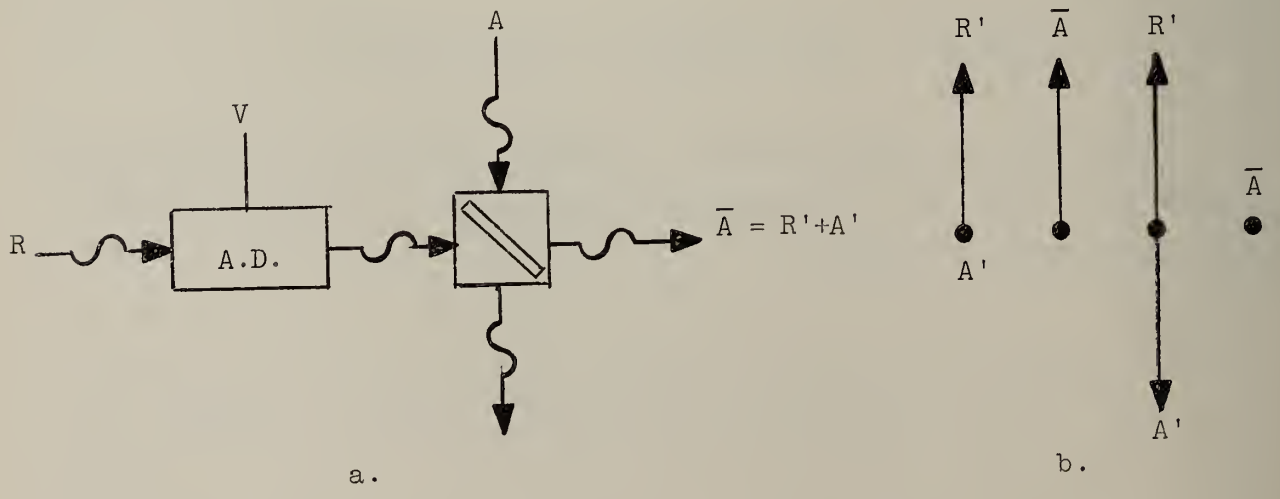
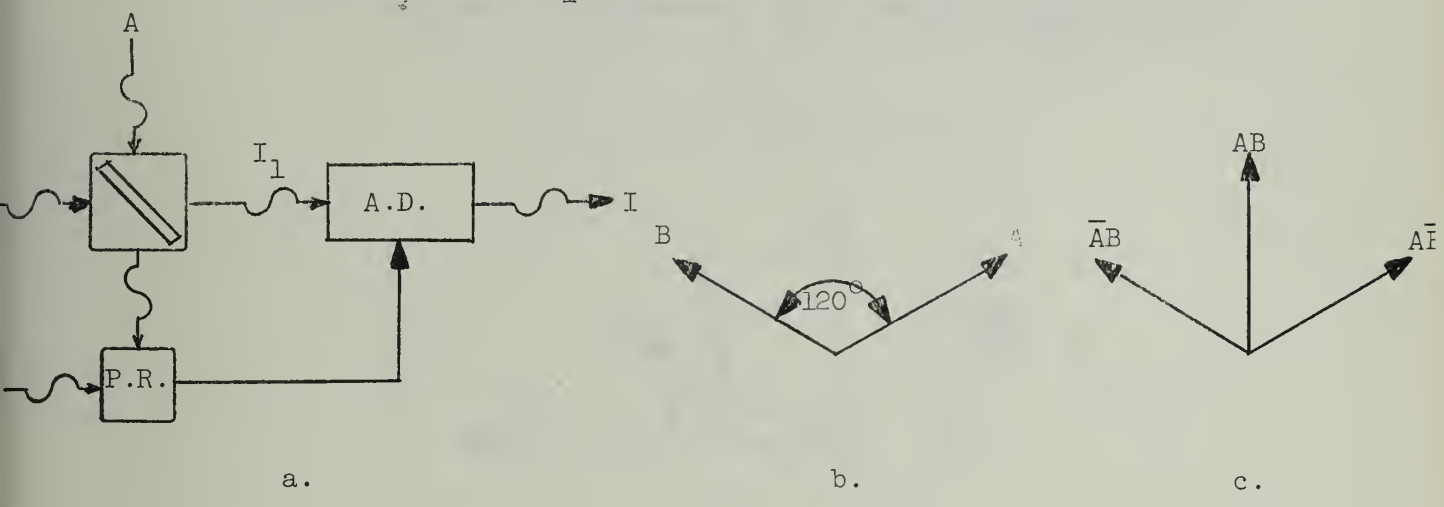


Figure 3. Optical NOT Circuit.

1.02.07.3 Optical OR Circuit

This is shown in Figure 4a. Inputs A and B are arranged to differ in phase by 120°, as in Figure 4b. Then if A or B or both are present the output I_1 has the same magnitude but one of three phases, according to Figure 4c; if A and B are both absent I_1 is zero.



a. b. c.

Figure 4. Optical OR Circuit.

The purpose of the "phase regulator" (P.R. in Figure 4a) is to produce an output I, of uniquely defined phase, which can then be used as an input to a following stage. The phase regulator monitors the input conditions, compares them with a reference beam R and generates an appropriate voltage for the phase correcting Anderson diode in the path of the output beam. Its components are shown in Figure 5a. As can be seen from Figure 5b, the amplitude of the phase correcting beam C is 0, 1 or $\sqrt{3}$ according as the input is $\bar{A}B$, AB or $A\bar{B}$.

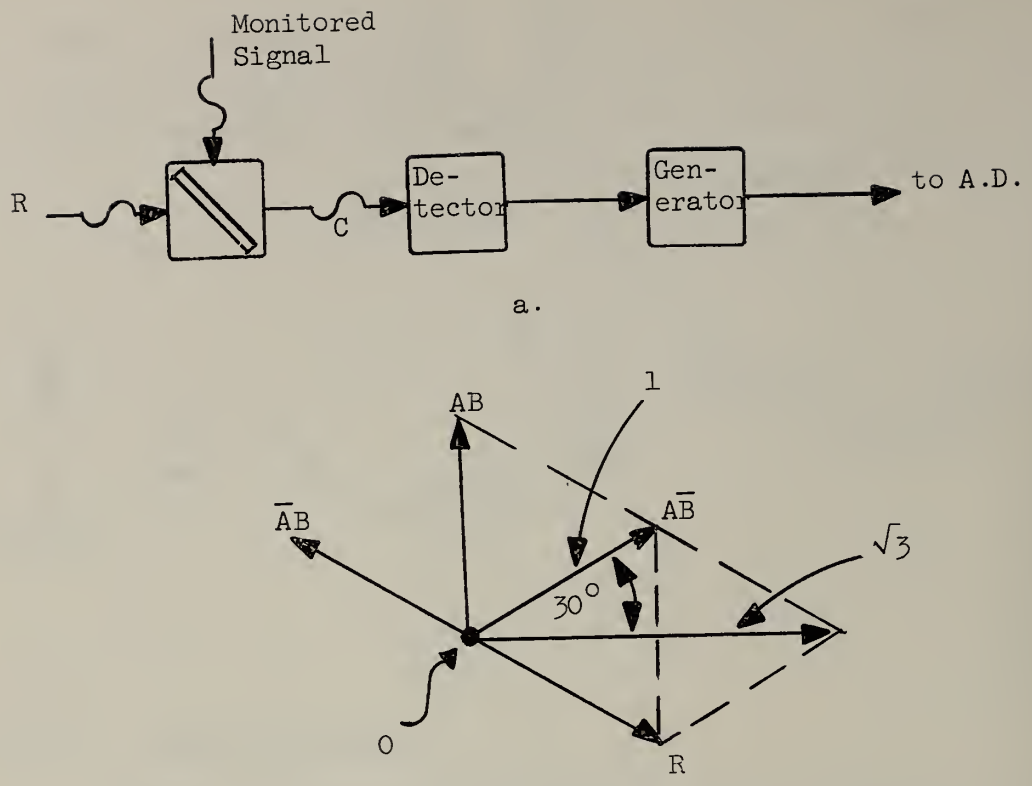


Figure 5. Phase Regulator.

1.02.07.4 Optical NAND Circuit

The NAND configuration of Figure 6a results when an additional beam splitter is added to the OR circuit, together with a bias beam C 120° out of phase with A and B, as shown in Figure 6b. As can be seen from Figure 6c, the amplitude of I_1 is zero only when A and B are both present.

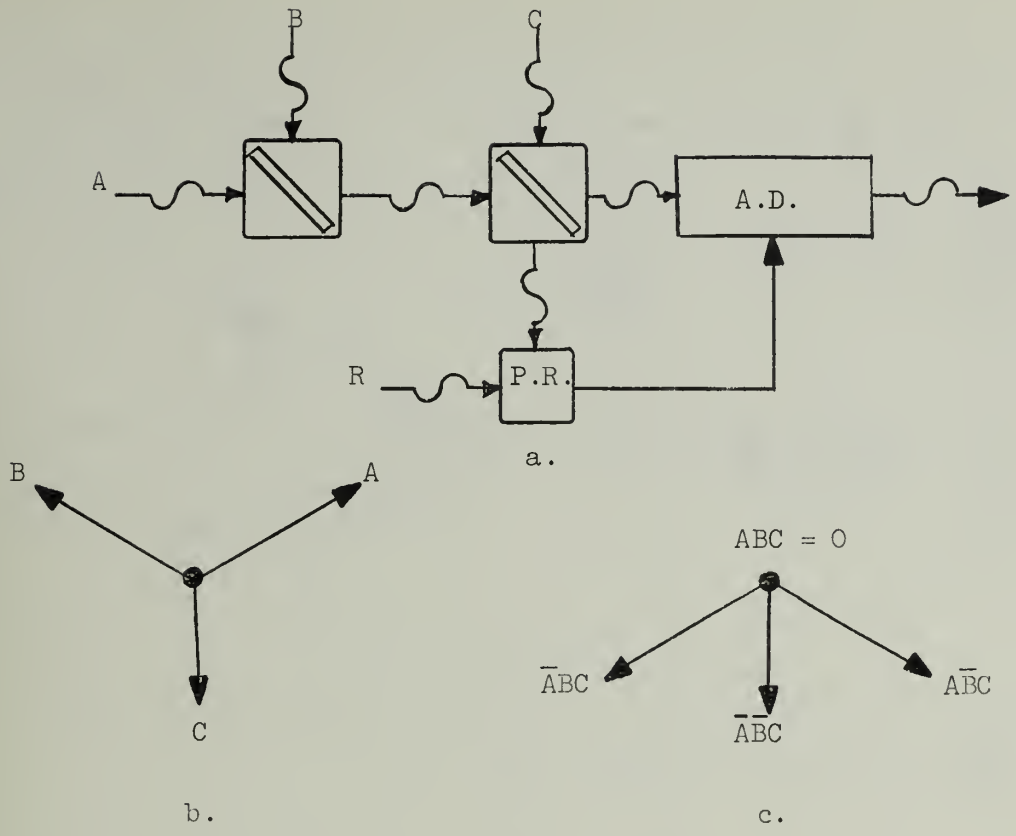


Figure 6. Optical NAND Circuit.

1.02.14 An Application of the Optical Differential Amplifier

1.02.14.1 Ruby Laser Diffraction Pattern

The optical differential amplifier (Quarterly Technical Progress Report, April-June 1965, p. 32) was used to measure the diffraction pattern from a pulsed ruby laser. Glass fiber light guides were used to sense the pattern and transmit it to the photo-inputs of the amplifier. The phototransistors were shielded to prevent stray light pick-up and a mechanical stage was designed and built to allow accurate movement of the light guides. The diffraction pattern thus measured showed as many maxima as did a black and white polaroid photograph of the laser output.

The frequency response of the amplifier is limited by the phototransistors to about 3 kc/s. It is recommended that a model with a greater frequency response be built for general use.

1.02.14.2 Integrator Circuit

Since the laser pulse lasts only about 0.5 ms, an integrator circuit was designed to allow measurements to be taken with an ordinary oscilloscope. The circuit is shown in Figure 1.

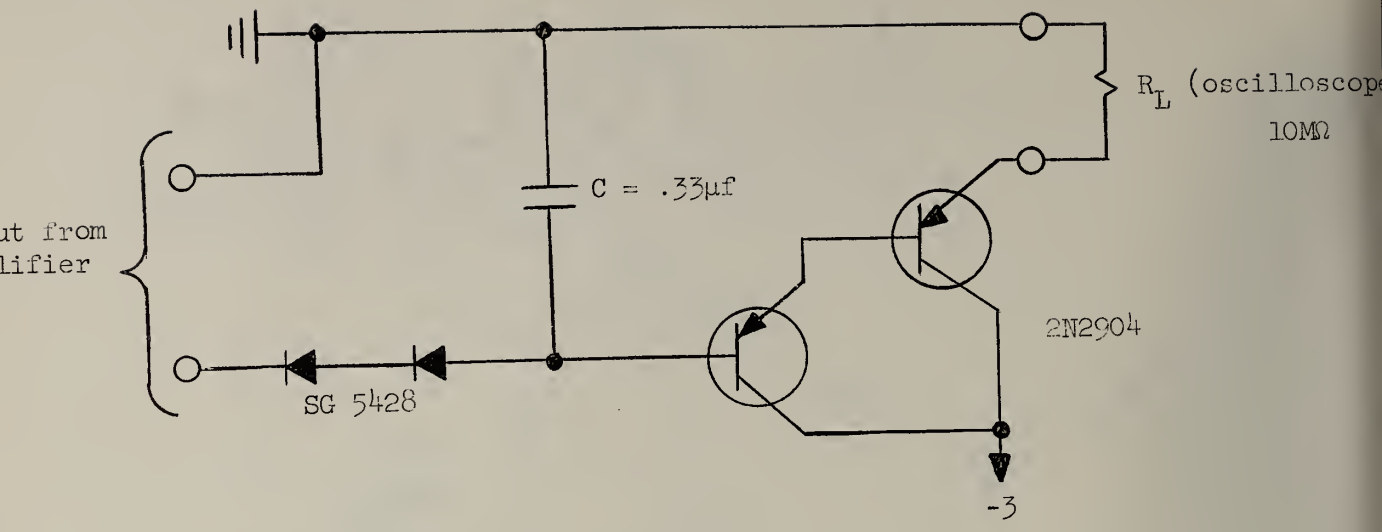


Figure 1. Integrator Circuit.

The time constant of this circuit is:

$$\tau = CR_{eq},$$

where $$\frac{1}{R_{eq}} = \frac{1}{2R_b} + \frac{1}{(\beta+1)^2 R_L} + \frac{1}{(\beta+1)r_c} + \frac{1}{r_c},$$

and R_b = reverse resistance of one diode,

β = current gain of one transistor,

r_c = collector-to-base resistance of one transistor (T-equivalent).

In the present case the limiting resistance is r_c, so that:

$$R_e \tilde{=} r_c \quad \text{and} \quad \tau \tilde{=} Cr_c .$$

Experimental measurement gave τ as about 15 seconds.

The peak diode current, I_c, may be determined from the equivalent circuit of Figure 2.

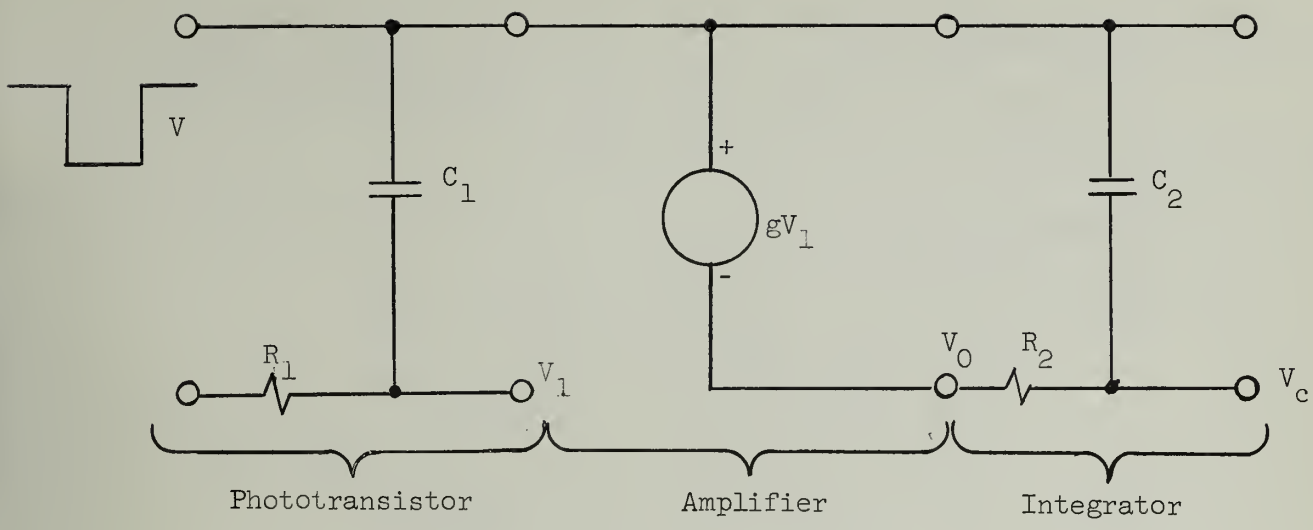


Figure 2. Equivalent circuit for peak diode current.

For a step input V, equivalent to some light intensity input:

$$V_1 = V\,(1-e^{-t/C_1R_1}),$$

$$V_0 = gV_1\ ,$$

$$V_C = V_0(1-e^{-t/C_2R_2}),$$

where $1/C_1R_1$ = 3kc/s (frequency response of phototransistors),

g = gain of amplifier

C_2 = 0.33 microfarad,

R_2 = forward series resistance of SG5428 diodes,

$\simeq$ 10 ohms.

Then $$V_C = (1-e^{-t/C_1R_1})(1-e^{-t/C_2R_2})\ gV$$

$$\simeq (1-e^{-t/C_1R_1})\ gV$$

since $C_2R_2 \gg C_1R_1$.

Now $$i_c = C_2\frac{dV_c}{dt} \simeq \frac{C_2}{C_1R_1}\,(1-e^{-t/C_1R_1})\ gV\ ,$$

so that the peak current, $i_c(0) = I_c$, is given by

$$I_c \simeq \frac{C_2}{C_1R_1}\ gV \simeq 10^{-3}\ gV \text{ amp.}$$

$$\simeq gV \text{ milliamperes.}$$

1.03.01 Random Sequence Coding

For a system which employs random pulse sequences as signals, the basic analog operation units have been developed.

1.03.01.1 Multiplier and Divider

Let V_0 = height of the standardized pulse,

τ = width of the standardized pulse,

N_x = average number of pulses in T seconds.

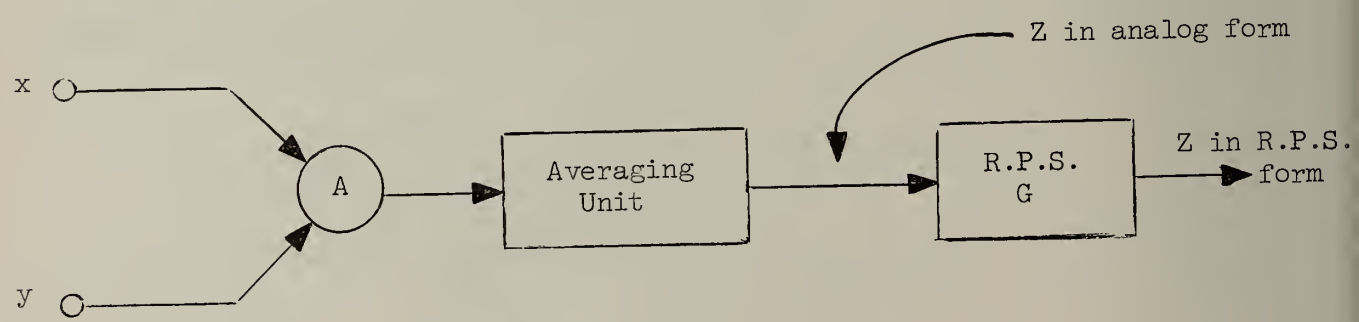
Then the average voltage (or current, depending on whether the sequence is voltage or current) of the random pulse sequence is given by

$$V_x = V_0 \frac{\tau}{T} N_x$$

Also we define an analog quantity x by the relative average value,

$$x = \frac{V_x}{V_0} = \frac{\tau}{T} N_x \qquad (1)$$

which is always less than unity, since $(\frac{\tau}{T})N_x$ is the probability that the random pulse sequence, $e_x(t)$, attains V_0. Then multiplication is performed by a single AND gate as shown in Figure 1. Since, in general, successive operations are performed on Z, a random pulse sequence generator which renormalizes the analog form of Z into the random pulse sequence form is provided.



R.P.S.G. = random pulse sequence generator

$$x = \frac{V_x}{V_o} = \frac{\tau}{T} N_x; \quad y = \frac{V_y}{V_o} = \frac{\tau}{T} N_y; \quad z = \frac{V_z}{V_o} = (\frac{\tau}{T} N_x)(\frac{\tau}{T} N_y) = xy$$

Figure 1. Multiplier.

Division is performed based on the principle of multiplication. This is shown in Figure 2.

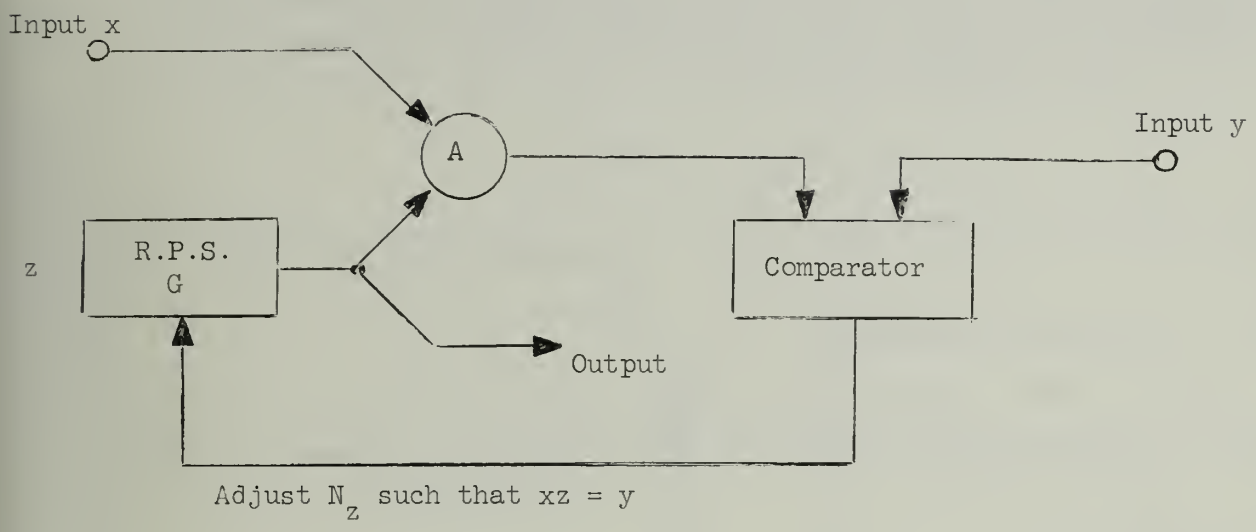


Figure 2. Divider.

Here the average repetition frequency, N_z/T of a random pulse sequence generator, is controlled by the output of the comparator, such that the average voltage of the dividend series y and that of the product-sequence of the divisor and the output are equal. Hence we have

$$xz = y$$

$$z = \frac{y}{x} \tag{2}$$

Since $z = (V_z/V_o) = (\tau/T)\ N_z < 1$, division in this case is possible only if $x > y$. Also note that in multiplication $z = xy$, $z < x$ and $z < y$. This again is a consequence of the conditions, $x < 1$ and $y < 1$. All these restrictions depend on the fact that operations are based on probability and our assignment of analog quantities to probability. It seems possible to relax the restriction by introducing different assignments (e.g. setting $1/x = (\tau/T)\ N_x$). This problem requires further investigation.

1.03.01.2 Adder and Subtracter

Here we propose a simple scheme in which operations are performed at the stage of averaging. Figure 3 shows the adder and subtracter. Current sources are assumed for the random pulse sequence sources. The R-C integrating circuit takes the average of the sum of $i_x(t)$ and $i_y(t)$.

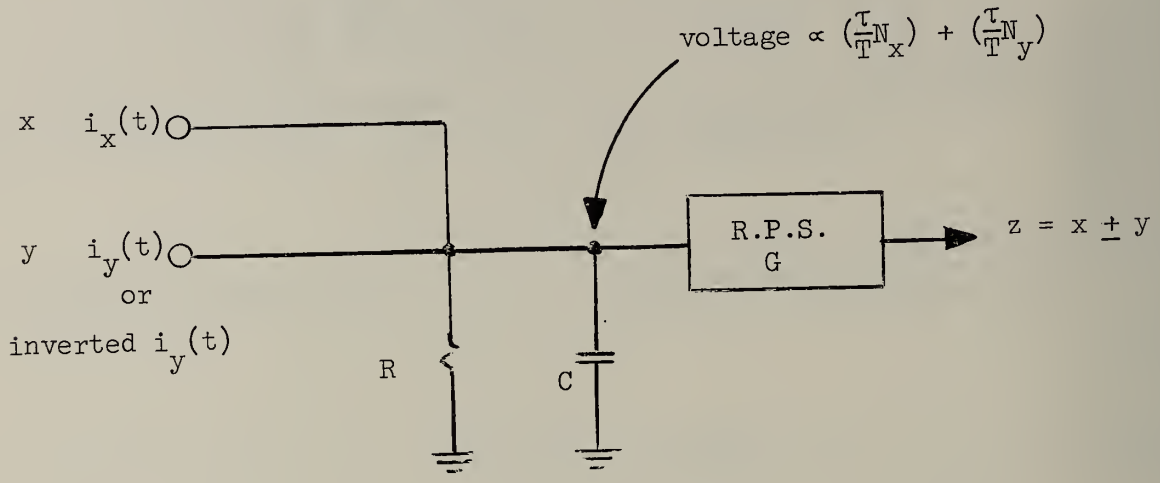


Figure 3. Adder and Subtracter.

If an inverted pulse sequence is introduced for y, the output gives z = x - y.

1.05 Tunneling Theory

The aim of this report is to justify the use of equilibrium Fermi-Dirac distribution functions in the Esaki Integral when treating the non-equilibrium situation of current flow in a tunnel diode.

1.05.06.1 Equilibrium Case

The energy of a conduction band electron in a semiconductor may be written as the sum of a potential energy and a kinetic energy:

$$E^{o} = E^{o}(\vec{r}, \vec{k}) = E_c^{o}(\vec{r}) + E'(\vec{k}), \tag{1}$$

where the potential energy, $E_c^{o}(\vec{r})$, is the conduction band edge in position space (constant for a homogeneous semiconductor). If -q denotes the electronic charge and $\Psi^{o}(\vec{r})$ the electrostatic potential in the semiconductor, $E_c^{o}(\vec{r})$ differs from $-q\Psi^{o}(\vec{r})$ only by an arbitrary constant, i.e.

$$\nabla_r E_c^{o}(\vec{r}) = -q\nabla_r \Psi^{o}(\vec{r}). \tag{2}$$

The distribution function in phase $(\vec{r}, \vec{k})$ space is the Fermi-Dirac one:

$$f^{o}(\vec{r}, \vec{k}) = 2(2\pi)^{-3} \{\exp[E^{o}-E_F)/\kappa T] + 1\}^{-1}, \tag{3}$$

where E_F is the Fermi energy, κ Boltzmann's constant, T the absolute temperature and the prefactors 2 and $(2\pi)^{-3}$ for spin and density of states in k-space, respectively.

1.05.06.2 Non-Equilibrium Case

With an applied electric field, $\vec{E}^{a}(\vec{r}) = -\nabla_r \Psi^{a}(\vec{r})$, the electron energy (1) changes to:

$$E = E(\vec{r}, \vec{k}) = E_c(\vec{r}) + E'(\vec{k}), \tag{4}$$

where now:

$$\nabla_r E_c(\vec{r}) = -q\nabla_r \Psi(\vec{r}) - q\nabla_r \Psi^{a}(\vec{r}), \tag{5}$$

i.e. the slope of the energy bands in position space is increased by $q\vec{E}^{a}$.

We seek the form of the distribution function, $f(\vec{r}, \vec{k})$, through the classical Boltzmann equation:

$$\partial f/\partial t + \dot{\vec{r}} \cdot \nabla_r f + \dot{\vec{k}} \cdot \nabla_k f = \partial f/\partial t)_{\text{collisions}} \tag{6}$$

For the steady state situation, $\partial f/\partial t = 0$. From (4), the electron velocity is $\dot{\vec{r}} = \hbar^{-1}\nabla_k E'$. Using (5), $\dot{\vec{k}} = \hbar^{-1}$ X force $= q\hbar^{-1}(\nabla_r \Psi^{o} + \nabla_r \Psi^{a})$. We write: $f = f^{o} + g$, so that g is a measure of the departure from equilibrium, and we make the constant relaxation time approximation:

$\partial f/\partial t)_{\text{collisions}} = -g/\tau$. Inserting these substitutions in (6) and subtracting out the equilibrium part of the equation, there remains:

$$(\nabla_k E').(\nabla_r g) + q(\nabla_r \Psi^o).(\nabla_k g) + q(\nabla_r \Psi^a).(\nabla_k g)$$
$$+ q(\nabla_r \Psi^a).(\nabla_k f^o) + (\hbar/\tau)g = 0. \qquad (7)$$

Now from (1), (2), and (3), since f^o can be written as an explicit function of energy only:

$$\nabla_r f^o = (df^o/dE^o)\ \nabla_r E_c^o = -q(df^o/dE^o)\ \nabla_r \Psi^o$$

$$\text{and}\quad \nabla_k f^o = (df^o/dE^o)\ \nabla_k E'.$$

We assume, by analogy, that f and therefore g may also be written as explicit functions of energy only, so that:

$$\nabla_r g = -q(dg/dE)(\nabla_r \Psi^o + \nabla_r \Psi^a) \qquad (8)$$

$$\text{and}\quad \nabla_k g = (dg/dE)\ \nabla_k E'. \qquad (9)$$

Substituting (8) and (9) into (7) gives immediately

$$g = -(q\tau/\hbar)(\nabla_r \Psi^a).(\nabla_k f^o),$$

$$\text{or}\quad g = (q\tau/\hbar)\ \vec{E}^a.(\nabla_k f^o). \qquad (10)$$

This result may be compared with the Taylor expansion:

$$f^o(\vec{r},\ \vec{k} + \vec{k}^a) = f^o(\vec{r},\ \vec{k}) + \vec{k}^a.\nabla_k f^o(\vec{r},\ \vec{k}) + \ldots.,$$

whence it is seen that, to a <u>first order</u>:

$$\vec{k}^a = (q\tau/\hbar)\ \vec{E}^a$$

$$\text{i.e.}\quad f(\vec{r},\ \vec{k}) \cong f^o(\vec{r},\ \vec{k} + q\tau\vec{E}^a/\hbar) \qquad (11)$$

Thus, the non-equilibrium distribution function is essentially Fermi-Dirac, but with the center of the Fermi sphere shifted from the origin to $\vec{k} = q\tau\vec{E}^a/\hbar$, which defines a drift mobility for electrons of:

$$\mu = q\tau/\text{effective mass}.$$

We also note the alternative form of (10):

$$g = q\tau\vec{E}^{a}.\vec{v}_{k}(df^{o}/dE^{o}), \tag{12}$$

showing that (11) may be written equivalently as:

$$f(E) \tilde{=} f^{o}(E + q\tau\vec{E}^{a}.\vec{v}), \tag{13}$$

where $\vec{v} = \dot{\vec{r}} = \hbar^{-1} \nabla_{k} E'$.

These results are also valid for valence band holes if the sign of q is changed.

1.11 Photochromic Storage

1.11.13.1 General

The investigation this period has been centered in three areas. The first is a device for holding the photochromic films, light sources, and other equipment in correct spatial relation while experiments are being performed on the films. The second area is concerned with the proper selection of light sources and color filters necessary for measuring the changes in optical density of the photochromic films. The third area consists of a first order search of photochromic literature.

1.11.13.2 Photochromic Exposure Box

The exposure box shown in Figure 1 is now in the final stages of completion. Its operation will be as follows:

The ultraviolet source at the top emits UV downward where it passes through a filter or filters removing all but the desired wavelength (≈3500 A). The UV then strikes the photochromic film that is oriented at 45^{o} with respect to the UV beam. Simultaneously, another light source, shown at the left, emits visible light which, after passing through filters, also impinges upon the photochromic film. In this case the filters are arranged to pass only the complement of the color of the activated photochromic film. (The first films that will be tested are clear until activated, whereupon they turn blue or purple-blue. The complement of these colors is a yellow of about 5800 A.) A portion of the light, that is a function of the optical density of the film, passes

through the film and is focused upon the light detector. The output of this detector is recorded as a function of time.

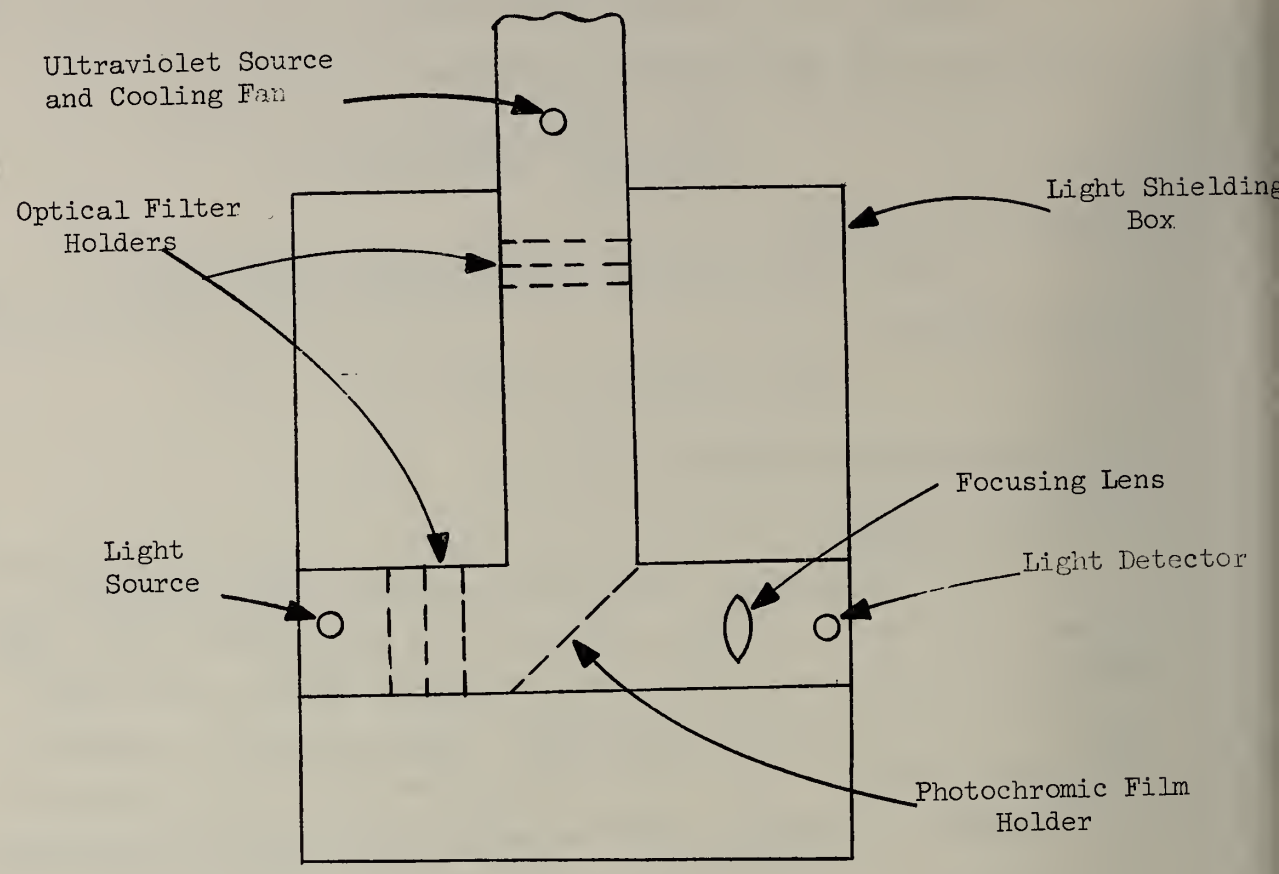


Figure 1.

After an initial calibration of the UV source it will then be possible to determine the optical density of a film as a function of the number of UV photons striking it.

1.11.13.3 Light Sources and Filters

There are two types of light sources needed, one in the ultraviolet region and one in the region of the complement of the activated film.

Preliminary experiments show that an ordinary General Electric Sunlamp has entirely adequate UV output. There is the possibility that future experiments may require a higher intensity of UV, calling for the use of a xenon or similar lamp.

The complementary source has been a greater problem. Ideally, it should be monochromatic with enough intensity to produce a measurable output from the light detector at the greatest optical density of the film being measured. Practically, this is not easily obtained.

The first films that will be tested should have a source close to 5800 A. It initially appears that a sodium lamp would be the best available, since it has an essentially monochromatic output at 5890 A; but, unfortunately it must be rejected since it is already known that some future films will require a shorter wavelength and thus a different source. Instead it was decided to use a wideband source (a 3 watt, 120 volt bulb with reflector) and derive approximate monochromaticity by optical filtering.

The filters serve two purposes. The first is to reject undesired emission from the UV and visible light sources, and the second is to control the intensity of the emissions striking the photochromic film.

For the ultraviolet source, the best rejection filter appears to be a Kodak Wratten #18A, which rejects all wavelenghts except those in the 3000 A - 4000 A band. The selection of rejection filters for the visible light source has been more difficult. A single filter that passes only the 5800 A band has not been located. Consequently, a simple FORTRAN program was written that can combine the characteristics of up to four individual filters and produce the resulting filter in graphical form. Experimentation, using this program, has indicated that a Kodak Wratten #16 filter combined with either a Kodak Wratten #38 or #40 filter should produce a 5800 A passband. Work in this area continues.

Intensity control will be obtained by the use of a set of Kodak Wratten #96 neutral density filters.

1.11.13.4 Literature

Baltzer (1) has written an easily understood introduction to photochromism. He also discusses tenebrescence which, though similar to photochromism, requires either heat or radiation of a different wave-

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1. Baltzer, Donald H., Photochemistry, Phototropy, Tenebrescence, Vari-Light Corporation, Cincinnati, Ohio, 1964.

length to produce reversal. Dessauer and Paris (2) give a thorough review of photochromism and, in particular, they point out how little is known of the actual chemical processes. Justice and Leibold (3) are concerned with measurements of a class of photochromic glasses. In their work they disagree with both Dessauer and Paris, and Baltzer, by claiming that, as far as they know, the photochromic glass with which they are familiar is totally reversible.

Using the work of the above authors it is hoped in the near future to obtain a theoretical equation relating the number of incident photons to the darkening of photochromic materials.

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2. Dessaur, R., and Paris, J. P., in Advances in Photochemistry, Vol. 1, Noyes, Hammond, Pitts, Interscience, 1963.

3. Justice, Benjamin and Leibold, F. B. Jr., Information Display, p. 23, Nov/Dec. 1965.

(Supported in part by the Atomic Energy Commission under Contract No. AT(11-1)-1469.)

Summary

The Artrix System has proceeded in the hands of John Esch, Al Irwin, William Kubitz, Peter Oberbeck and David Rollenhagen. In the following pages they discuss the preliminary system, which has now been built, an analysis of displacement errors, design of the Processor and that of a digitally controlled variable gain amplifier.

Further progress in Pattern Transform Analysis is reported by Douglas Sand.

2.10 The Artrix System

2.10.11.1 Preliminary System

The preliminary system described in the last report (Quarterly Technical Progress Report July-September 1965, 2.10.08.5, p. 34) and shown in Figure 3 (op. cit.) has been built. An inexpensive closed circuit television system was purchased to provide the read out vidicon and display. Deflection circuitry for the memotron was designed and operates synchronously with the deflection circuitry of the display. A light pen was constructed using a Texas Instruments H38 photodiode, followed by several stages of amplification to drive the grid of the memotron.

The resolution of the storage system was severely reduced because of the persistance of the phosphor coating on the display CRT and the poor response time of the photodiode. As the beam crosses within the beamwidth of the pen, the time required for the light intensity to decay to seven percent of the peak value is 33 msec. This is approximately the time required for each complete television frame, which means that the phosphor does not have time to decay fully before it is again excited by the electron beam. Neglecting the response time of the photodiode, the

output pulse from the pen is about 33 msec wide. In order to achieve the desired resolution, which is the division of a horizontal line into 500 parts, the output pulse width must be no greater than 0.1 μsec. (This is 1/500 of the time required for scanning one horizontal line.) This comparatively small pulse width may be approached by detecting the leading edge of the 33 msec output pulse and sharpening it via successive differentiations and amplifications. The factor limiting the pulse width then becomes the response time of the photodiode, which must be in the nanosecond range.

The proposed solution to the resolution problem is the employment of a fast photodiode, several stages of amplification and differentiation, and a single shot (either a monostable blocking oscillator on a monostable multivibrator) to provide the 0.1 μsec output pulse.

Another requirement of the photodiode in the light pen is that its peak spectral response lie in the vicinity of 4000 to 6500 angstroms, the spectral emission range of the phosphor coating on the display CRT. The light pen itself must be so constructed that it detects the light from one horizontal line only, in order to avoid interference from the light of adjacent lines.

The video output from the camera was inverted, which resulted in a negative picture on the display. This was necessary in order for the pen to detect the presence of the beam on a blank screen. The result is dark writing on a light screen. Writing is possible without inversion, if the intensity of the display is adjusted to give a bright enough illumination. In this case however, as a larger and larger area of the display is written the unwritten area of the display decreases in brightness because the automatic light compensation of the camera maintains a constant average brightness. This results in a brightness for the unwritten area which is insufficient to produce an output from the photodiode. Thus the entire screen cannot be written. Inversion of the video eliminates this problem.

2.10.11.2 Deflection Circuitry

Two cathode followers, constituting low impedance sources of horizontal and vertical synch pulses, were designed and wired into the display. Horizontal and vertical sync pulse amplifiers were followed by a series of pulse choppers and shaping circuits. The pulses were used

to sync two astable multivibrators, which in turn triggered the linear sweep circuits. Following an inversion stage, the sawtooth outputs were amplified by push pull amplifiers to give the voltages necessary for full deflection of the Memotron beam. Provisions for DC beam centering, AC gain and AC balance were included in the circuits.

2.10.08.3 Displacement Errors in the Artrix System

Figure 1 shows schematically the Display-Light Pen-Memotron-Iconoscope loop of the Artrix System. The pen can be aimed at any point of the Display, and the function of the System is to store the corresponding point in the Memotron and transfer it back to the Display via the Iconoscope, where it appears as a dark spot on a light background (cf. section 2.10.11 of this Quarterly Technical Progress Report). Because of time delays and non-linearities in the loop the dark spot may not appear exactly at the point at which the pen is aimed, and this error in positioning is termed displacement error. The discussion that follows is intended as a preliminary analysis of such error. Errors due to other causes will be treated in a later report.

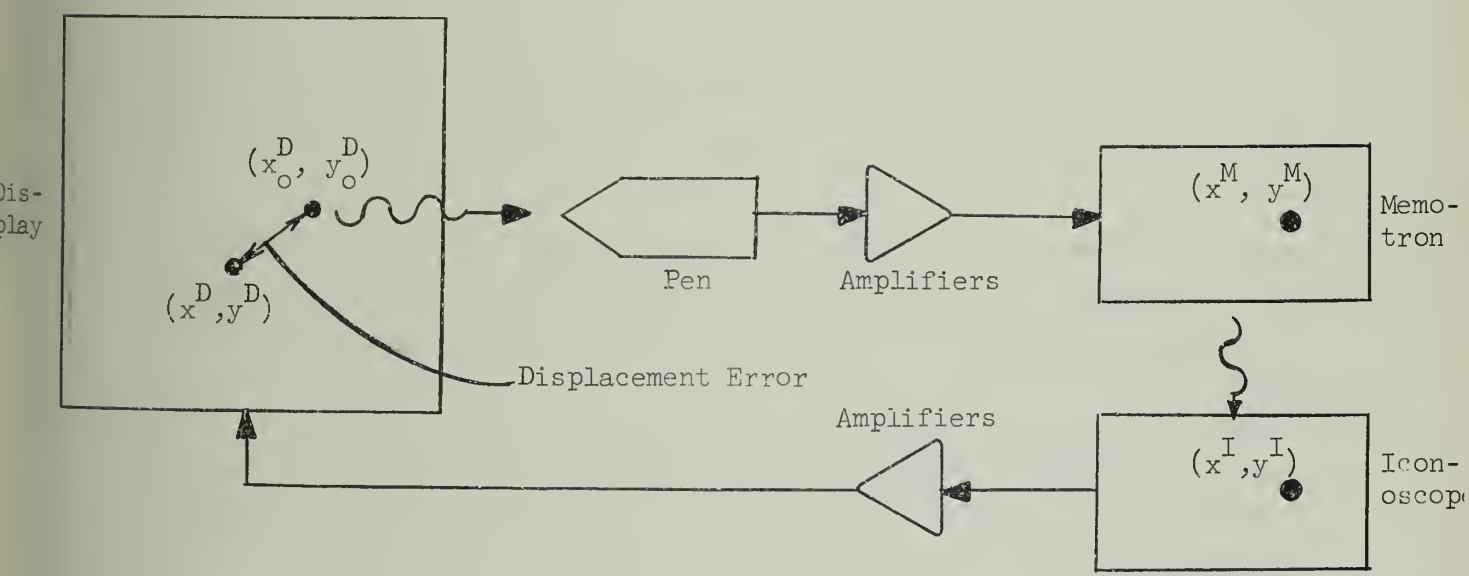


Figure 1. Artrix Storage and Display Loop.

It is assumed that the electron gun sweeps of Display, Memotron, and Iconoscope are synchronized. In what follows, t is time measured from the start of a line sweep and modulo one line duration; thus t = 0

at the start of each line. The coordinates of a point (x^D, y^D) on the n^{th} line of the display can then be represented by:

$$x^D = At + \alpha_n^D(t),$$

$$y^D = y_n + \beta_n^D(t),$$

where A is a constant, y_n is the ideally constant ordinate of the n^{th} line where n = 1, 2, ... and $\alpha_n^D(t)$ and $\beta_n^D(t)$ are functions representing the non-linearity of the display trace. Similar expressions can be written for the Memotron and Iconoscope sweeps, with the same A since the sweeps are synchronized, but with superscripts changed from D to M and I, respectively, to give the appropriate distortion function for each device. Suppose that at time t_o the Light Pen 'sees' the point:

$$\begin{aligned} x_o^D &= x^D(t_o) = At_o + \alpha_n^D(t_o), \\ y_o^D &= y^D(t_o) = y_n + \beta_n^D(t_o). \end{aligned} \tag{1}$$

This is transmitted via amplifiers and shaping and deflection circuitry to the Memotron, where it appears after some delay, τ_1. Thus its coordinates in the Memotron are:

$$\begin{aligned} x^M &= A(t_o + \tau_1) + \alpha_n^M(t_o + \tau_1), \\ y^M &= y_n + \beta_n^M(t_o + \tau_1). \end{aligned} \tag{2}$$

(It may be assumed without loss of generality that the picture sizes in Display, Memotron and Iconoscope are the same; the argument is unchanged by introducing scaling factors between one set of coordinates and the next.)

An image of (x^M, y^M) is then formed on the mosaic of the Iconoscope, but, because of distortion in, and misalignment of the optical system, its coordinates take the form:

$$\begin{aligned} x^I &= x^M + \gamma(x^M, y^M), \\ y^I &= y^M + \delta(x^M, y^M), \end{aligned} \tag{3}$$

where the functions, γ and δ, represent deviations from the ideal position of the image. It is important to note that γ and δ can be changed

by moving the Iconoscope--if the lens system were perfect, they could be made zero by proper alignment--and this fact enables some adjustment of the displacement error to be made, as will be seen below. The time at which the Iconoscope sweep picks up (x^I, y^I) depends, of course, not only on γ and δ but also on the distortion functions, $\alpha_n^I(t)$ and $\beta_n^I(t)$ of the Iconoscope sweep. This time, again modulo one line duration, is denoted by $t_o + \tau_1 + \tau_2$, where now τ_2 may be positive or negative. Also, δ may be large enough to displace the image from line n to line m of the Iconoscope mosaic, so that (x^I, y^I) is given by:

$$x^I = A(t_o + \tau_1 + \tau_2) + \alpha_m^I(t_o + \tau_1 + \tau_2)$$
$$y^I = y_m + \beta_m^I(t_o + \tau_1 + \tau_2) \qquad (4)$$

Evidently, if the forms of α, β, γ, δ are known, γ_2 is uniquely determined by (3) and (4).

The final step in the loop is the transmission of (x^I, y^I) back to the Display, again via miscellaneous circuitry, this time involving a delay τ_3, where the point appears at the coordinates:

$$x_\tau^D = x^D(t_o + \tau_1 + \tau_2 + \tau_3) = A(t_o + \tau_1 + \tau_2 + \tau_3) + \alpha_m^D(t_o + \tau_1 + \tau_2 + \tau_3)$$
$$y_\tau^D = y^D(t_o + \tau_1 + \tau_2 + \tau_3) = \quad y_m \quad + \beta_m^D(t_o + \tau_1 + \tau_2 + \tau_3) \qquad (5)$$

Hence, from (1) and (5), the displacement error is:

$$\Delta x = x_\tau^D - x_o^D = A(\tau_1 + \tau_2 + \tau_3) + \alpha_m^D(t_o + \tau_1 + \tau_2 + \tau_3) - \alpha_n^D(t_o) \qquad (6)$$
$$\Delta y = y_\tau^D - y_o^D = y_m - y_n + \beta_m^D(t_o + \tau_1 + \tau_2 + \tau_3) - \beta_n^D(t_o)$$

Formally, $|\Delta x|$ and $|\Delta y|$ could be minimized, perhaps even be reduced to zero, by suitable choice of γ and δ of equation (3). But this is more easily achieved experimentally, by moving the Iconoscope with the Light Pen in a fixed position.

2.10.05.4 Processing Unit

The first operations that have been considered are the automatic construction of circles and straight line segments. Each is to be specified, with the light pen, by two points in succession: for the circle, its center (x_1, y_1) and any point (x_2, y_2) on its circumference; for the line segment, its end points (x_1, y_1) and (x_2, y_2). To obtain the desired circle the Processor generates the sweep:

$$x = x_1 + rt \cos \omega t,$$

$$y = y_1 + rt \sin \omega t,$$

where $r \ll \omega$, beginning at time $t = 0$; i.e. a circle of slowly expanding radius. At some later time, τ, when $x = x_2$ and $y = y_2$ simultaneously, the radial expansion is stopped, leaving the desired circle:

$$x = x_1 + rt \cos \omega t \qquad t > \tau$$

$$y = y_1 + rt \sin \omega t$$

To obtain a line segment the Processor generates the sweep:

$$x = (x_2 - x_1)|\sin \omega t| + x_1$$

$$y = (y_2 - y_1)|\sin \omega t| + y_1$$

The system contains seven nine-bit counters, X, Y, X_1, Y_1, X_2, Y_2 and R (Figure 1). X and Y count continuously and specify horizontal and vertical coordinates. The X counter also serves to synchronize the entire system. X_1 and Y_1 equal X and Y until point (x_1, y_1) is specified, when they stop. The X_1 and Y_1 outputs are converted to analog. What follows thereafter depends on whether a circle or a line is being drawn. If it is a circle, X_2 and Y_2 equal X and Y until point (x_2, y_2) is specified, when they stop, are converted to analog and R begins its count. The R output controls variable gain amplifiers for cos ωt and sin ωt, and the analog signals

$$x = x_1 + R \cos \omega t$$

and $$y = y_1 + R \sin \omega t$$

are generated. R is stopped by the simultaneous coincidence of $x = x_2$ and $y = y_2$.

For straight line construction, X_2 and Y_2 are started when (x_1, y_1) is specified and stopped by (x_2, y_2). Only the sine wave generator is used and its rectified output is taken to form the given line. These processes are shown in Figure 2.

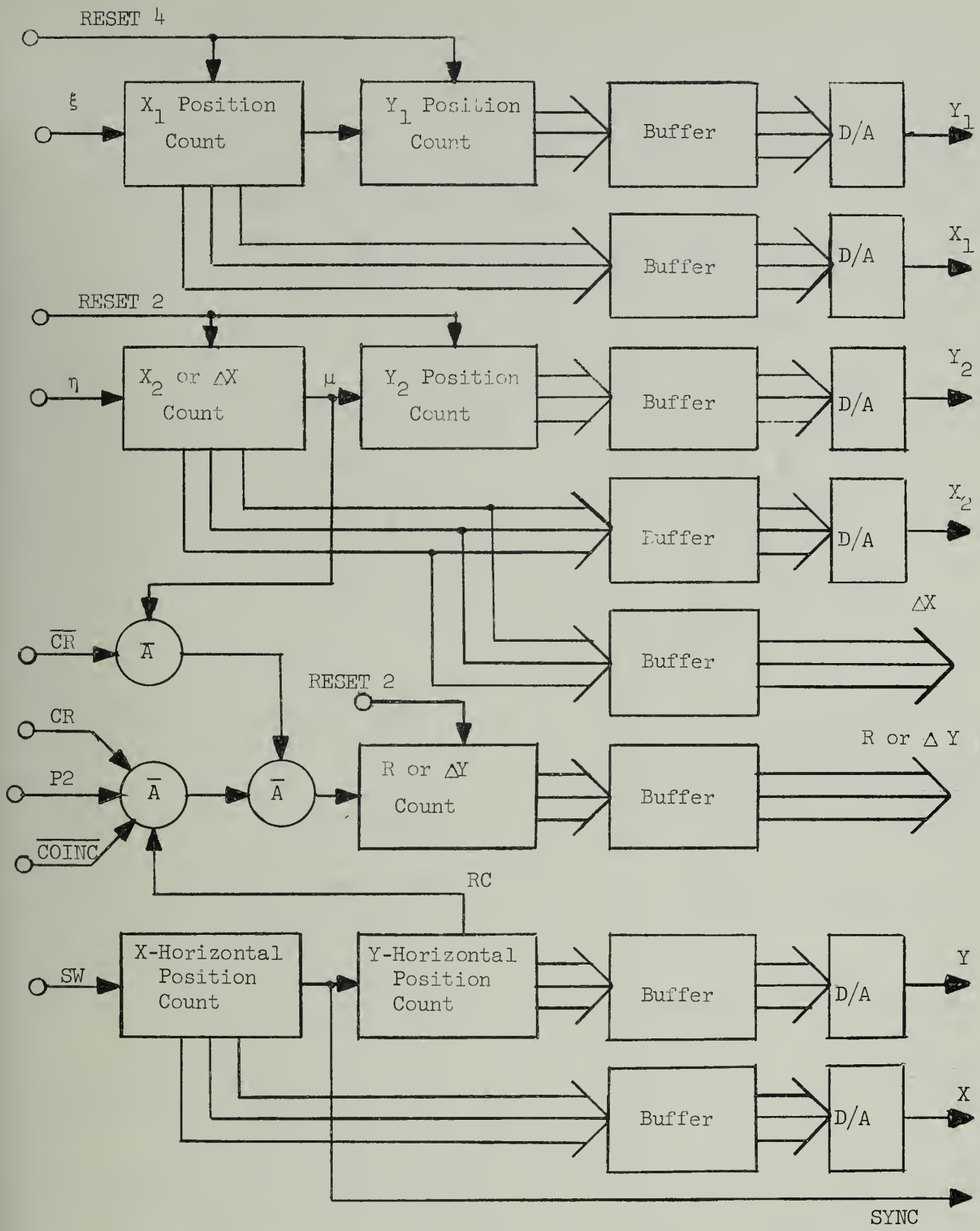
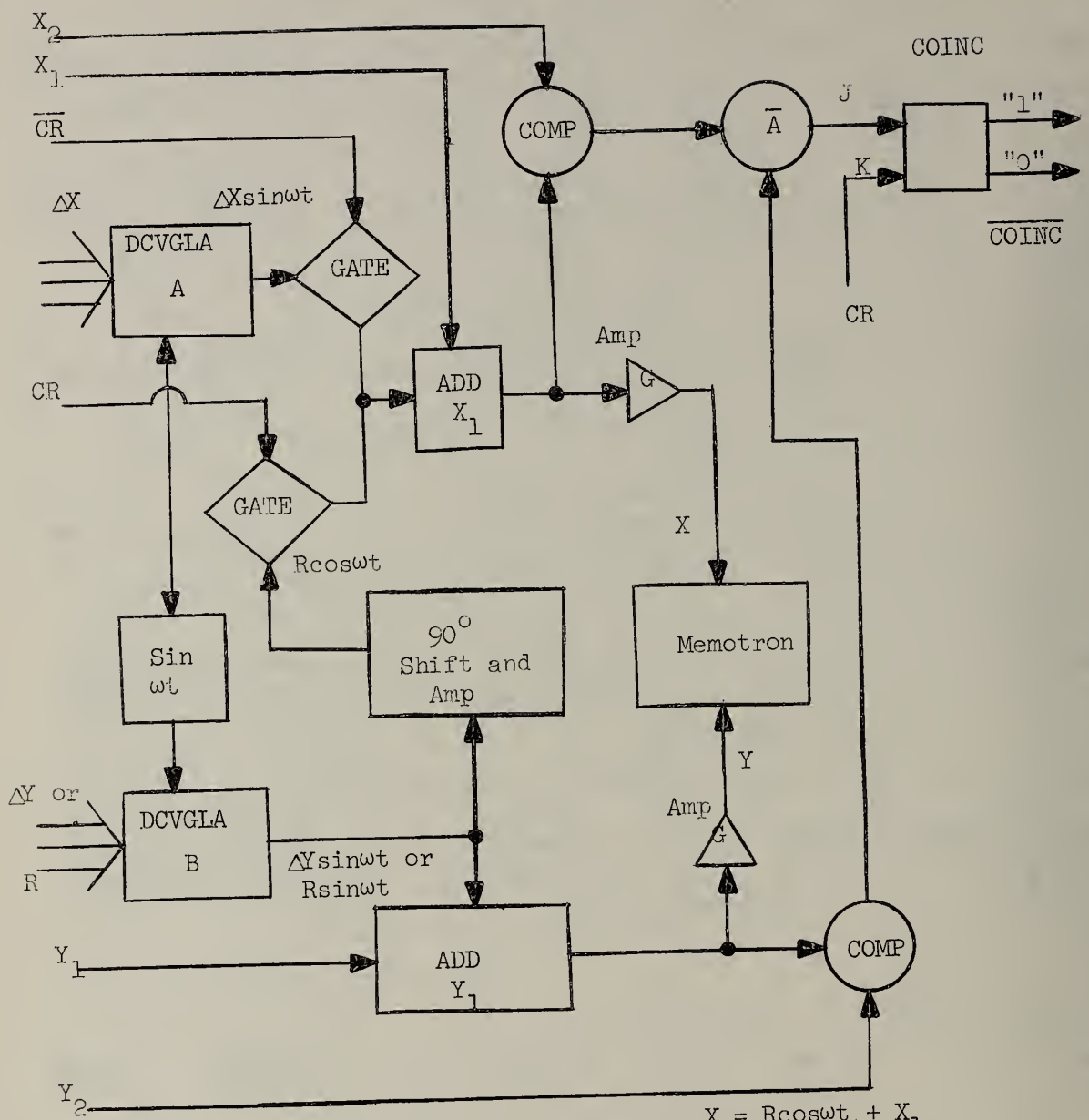


Figure 1. Analog and Digital Signals For Generating Lines and Circles.



$$\text{CR} = \begin{cases} \text{"1" Circle Operation} & \begin{cases} X = R\cos\omega t + X_1 \\ Y = R\sin\omega t + Y_1 \end{cases} \\ \text{"0" Line Operation} & \begin{cases} X = \Delta X\sin\omega t + X_1 \\ Y = \Delta Y\sin\omega t + Y_1 \end{cases} \end{cases}$$

$$\Delta X = x_2 - x_1$$

$$\Delta Y = y_2 - y_1$$

Figure 2. Line and Circle Generation.

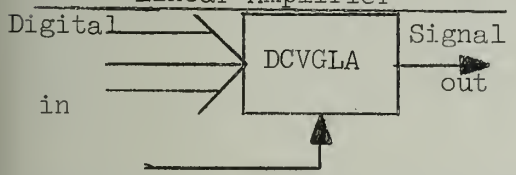
The following pages illustrate block diagram elements and logic signals. The block diagram elements are in three parts: LOGIC, ANALOG, and HYBRID elements. Under each appear the name of the element and its characterizations. The description of logic signals lists all logic signals which appear in the block diagrams and explains what each is and in some cases gives its logical function equivalent.

Explanation of Block Diagram Elements

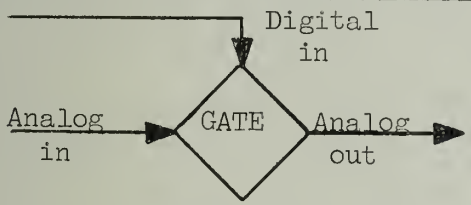
HYBRID

9 Bit Digital to Analog Convertor

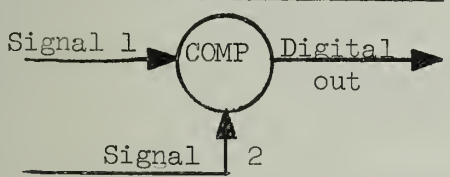
Digitally Controlled Variable Linear Amplifier



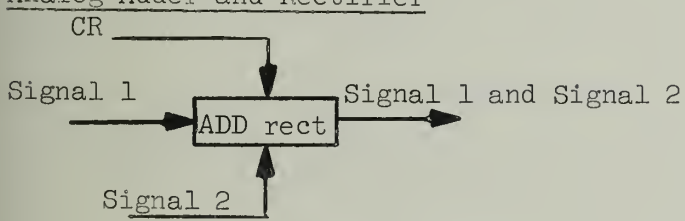
Digitally Controlled Analog Gate



Analog Comparer With Digital Output

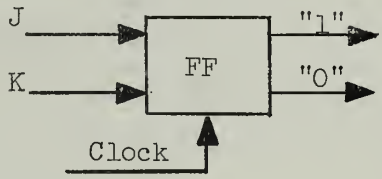


Analog Adder and Rectifier

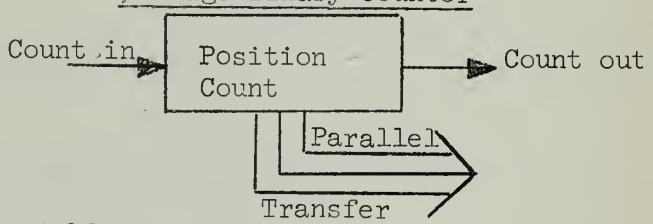


LOGIC

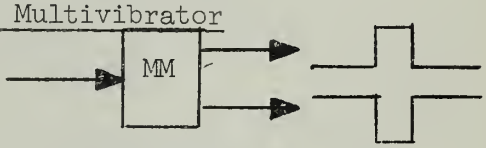
JK Flip Flop



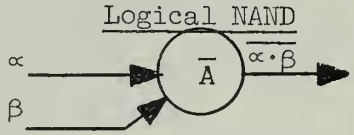
9 Stage Binary Counter



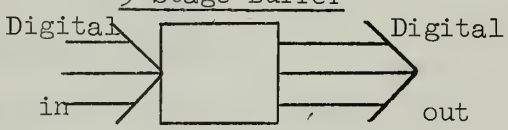
Monostable Multivibrator



Logical NAND

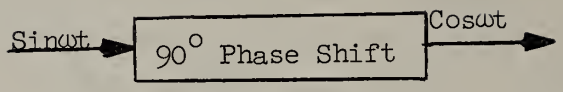


9 Stage Buffer

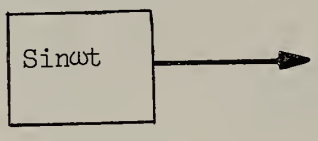


Linear Amplifier

90° Phase Shift



Sinωt Generator



Logic Signals

1. CR = Set for a circle operation.
   Reset for a line operation.

2. P1 = Set when (x_1, y_1) is designated.
   Reset at the beginning of each operation.

3. P2 = Set when (x_2, y_2) is designated.
   = Reset at the beginning of each operation.

4. COINC = Set when both $y = y_2$ and $x = x_2$ at the same time.
   Reset at beginning of each circle operation.

5. OF = Set at the beginning of each operation.
   Reset when horizontal count overflows.

6. SYNC = "1" to "0" transition when horizontal count overflows.

7. SW = 16.128 meg. hertz square wave.

8. RC = Square wave whose frequency equals the rate of the expanding circle.

9. RESET1 = "1" to reset x and y position counters to "0".

10. RESET2 = "1" to reset x_2 and y_2 and R position counters to "0".

11. ξ = $\overline{P1}$.SW v OF

    = Counts in sync with horizontal and vertical count until (x_1, y_1) is designated.

12. η = $CR.\overline{P2}.SW \vee \overline{P2}.P1.SW \vee OF$

= For a circle operation it counts in sync with the horizontal vertical count until (x_2, y_2) is designated.

For line operation it counts from (x_1, y_1) to (x_2, y_2).

13. μ = η counted down by a nine stage binary counter.

14. Ψ = $CR.P2.\overline{COINC}.RC \vee \overline{CR}.M$

For a circle operation it is the square wave whose frequency equals that of the expanding radius at the circle. It starts when (x_2, y_2) is designated and stops when coincidence is reached. For a line operation it equals μ.

2.10.09.5 Processing Unit Hybrid Circuitry Design

For most of the processor, standard integrated circuits and other high-speed logic will be used. All this logic can be bought, and none of it will be designed in the laboratory.

There are, however, several hybrid circuits that will have to be designed and built in the laboratory. These are the ones that have to perform unusual functions that are seldom encountered, and hence are not commercially available. They also include some standard circuits that, due to special requirements, will be designed here.

The circuits under consideration at present are:

1. D/A converter
2. Digitally controlled variable gain amplifier (DC VGLA)
3. Analog comparator with digital output
4. Phase shift amplifier
5. Sine wave generator
6. Interface buffers (logic level changes).

The items described in #1, 4, 5, 6 are for the most part well established circuits and no problem is expected in their design.

The main part of the project will be to design the digitally controlled variable gain linear amplifier, and the analog comparator with digital output.

So far, most of the work has been concentrated on the amplifier. The need for digital control arises from the fact that the position of a point is known in digital form, and that the peak amplitude of a sine-wave has to be proportional to that digital signal.

The amplifier is to be controlled by 9 digital bits giving 2^9 or 512 different output values. In other words, it will have a gain of $(0 \rightarrow 511)$ k, where k is some gain constant.

The basic idea of the amplifier is to have a constant voltage source and switch in (by electronic means) various resistors of $2^n R$, n = 0, 1, 2 . . .8. (Figure 1.) The current I following out of the constant voltage source will be proportional to the sum of the currents flowing through the resistors. The maximum current that can flow is:

$$I = I_0 + \frac{I_0}{2} + \frac{I_0}{4} \cdot \cdot \cdot \frac{I_0}{28} = 2\left(\frac{511}{512}\right) I_0 = 2\left(\frac{511}{512}\right) \frac{V}{R_0}$$

In this way the output current can have any value of the form:

$$\frac{2n}{512} \frac{V}{R_o}, \quad \text{for} \quad n = 0, 1, \ldots, 511$$

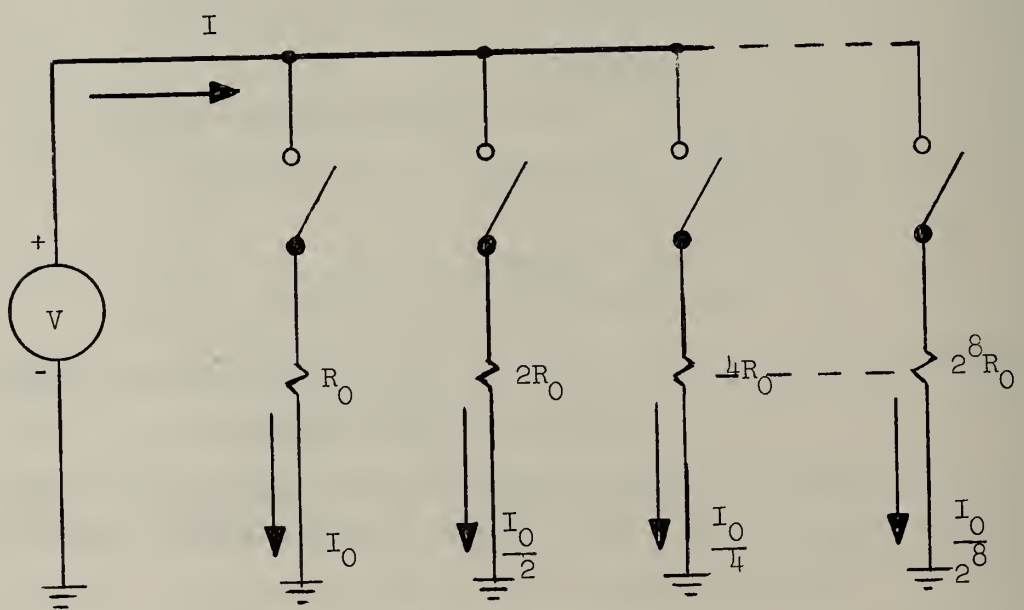


Figure 1. Basic Circuit of DC VGLA.

Since the values of the Resistors R_0 to $2^8 R_0$ cover quite a range, some of the smaller signals are lost in the noise-level of the circuit. To prevent this it is possible to mix the output of a 4 and 5 bit amplifier together, with one of them having the proper attenuation to establish the correct output ratio.

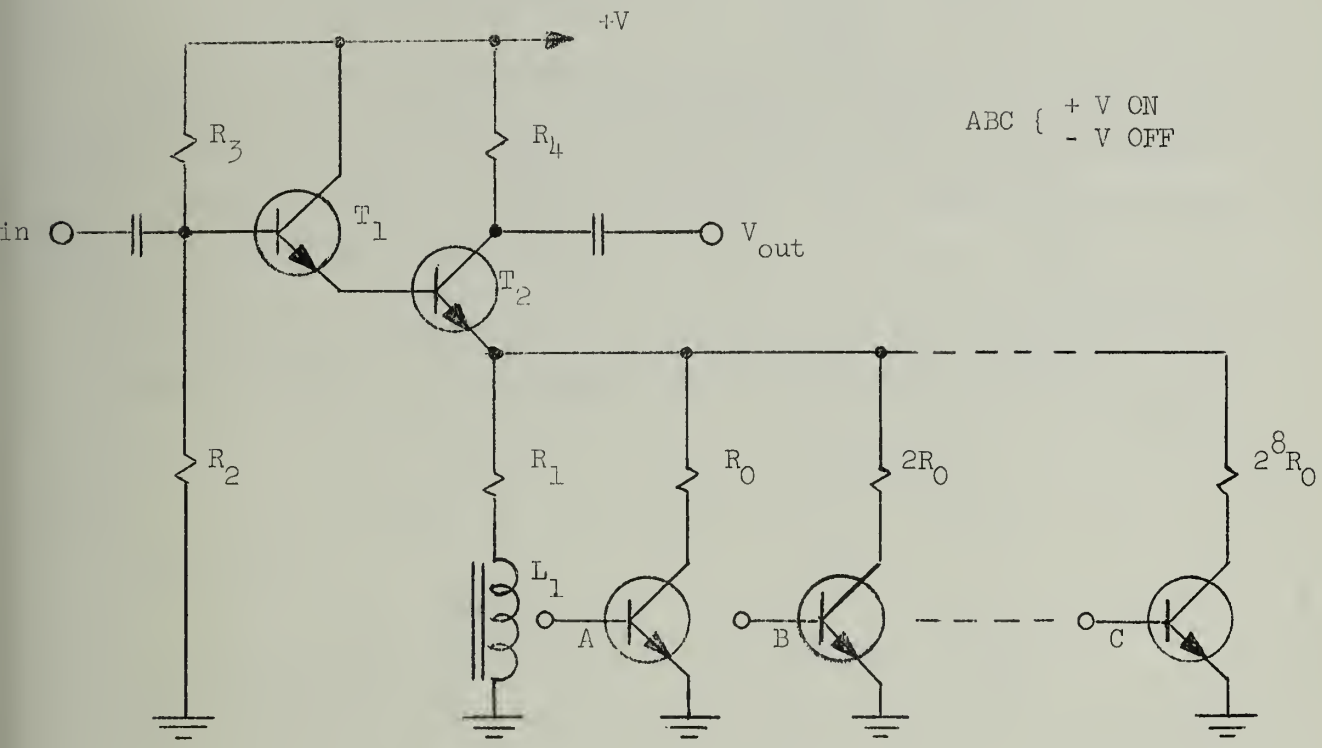


Figure 2. Practical Circuit of DC VGLA.

2.12 Pattern Transform Analysis

2.12.12.1 Diffraction Patterns and Fourier Transforms

The Fraunhofer diffraction pattern of a planar transparency pattern is equivalent to the Fourier transform of the original pattern. That is, by calculating the Fourier transform of a pattern one has a representation of the optical diffraction pattern. If the pattern can be designated by a set of discrete values the Fourier transform can readily be calculated by a digital computer program.

2.12.12.2 Fourier Integrals and Series in Two Dimensions

A function $f(x,y)$ (of two independent variables x and y) and its Fourier transform $F(\alpha, \beta)$ are related by the transform pairs [2]

$$F(\alpha, \beta) = \int_{-\infty}^{\infty}\int f(x, y)\, e^{-j(\alpha x + \beta y)}\, dxdy, \tag{1}$$

$$F(x, y) = \frac{1}{4\pi^2}\int_{-\infty}^{\infty}\int F(\alpha, \beta)\, e^{j(\alpha x + \beta y)}\, d\alpha d\beta. \tag{2}$$

When applied to optics the function $F(x, y)$ represents the amplitude transmission of a planar pattern and the function $F(\alpha, \beta)$ represents the amplitude and phase of the Fraunhofer diffraction pattern (where α, β are distance coordinates related to the spatial frequencies of $f(x, y)$). To represent the transmission pattern meaningfully, $f(x, y)$ can be non-zero over a region no larger than that of the original pattern. It is convenient to normalize this non-zero region to a unit square centered at the x, y-origin, so that

$$F(\alpha, \beta) = \int_{-\frac{1}{2}}^{\frac{1}{2}}\int f(x, y)\, e^{-j(\alpha x + \beta y)}\, dxdy, \tag{3}$$

It would be useful to relate $f(x, y)$ to a Fourier series expansion. This can be done by constructing a doubly periodic function $f_1(x, y)$ which is equal to $f(x, y)$ over the unit square. That is,

$$f_1(x, y) = f(x, y) \quad \text{for } |x| \le \frac{1}{2}, \ |y| \le \frac{1}{2},$$

$$f_1(x, y) = f_1(x + 1, y) = f_1(x, y + 1) = f(x + 1, y + 1). \tag{4}$$

The function $f(x, y)$ is then the product of $f_1(x, y)$ and a two-dimensional unit rectangle pulse:

$$f(x, y) = p(x, y) \cdot f_1(x, y),$$

where

$$p(x, y) = \begin{cases} 1 & \text{for } |x| \le \frac{1}{2}, \ |y| \le \frac{1}{2} \\ 0 & \text{otherwise.} \end{cases}$$

The periodic function $f_1(x, y)$ can be expressed as a two-dimensional Fourier series [2]:

$$f_1(x, y) = \sum_{m,\, n\, =\, -\infty}^{\infty} E_{mn} e^{j2\pi(mx + ny)} , \tag{5}$$

where

$$E_{mn} = \frac{1}{4\pi^2} \int_{-\frac{1}{2}}^{\frac{1}{2}} \int_{-\frac{1}{2}}^{\frac{1}{2}} f_1(x, y)\, e^{-j2\pi(mx + ny)}\, dxdy. \tag{6}$$

Equation (5), using the unit rectangle pulse, can then replace $f(x, y)$ in equation (3) for the Fourier transform $F(\alpha, \beta)$:

$$F(\alpha, \beta) = \int_{-\frac{1}{2}}^{\frac{1}{2}} \int_{-\frac{1}{2}}^{\frac{1}{2}} \left[\sum_{m,\, n\, =\, -\infty}^{\infty} E_{mn} e^{j2\pi(mx + ny)} \right] e^{-j(\alpha x + \beta y)}\, dxdy. \tag{7}$$

By convolution (or the theory of distributions or the Limit of Riemann Sums) the above double integral can be simplified. We have

$$\int_{-\frac{1}{2}}^{\frac{1}{2}} e^{j(2\pi m - \alpha)x}\, dx = \operatorname{sinc}\left(\frac{2\pi m - \alpha}{2}\right).$$

This gives

$$F(\alpha, \beta) = \sum_{m,\, n\, =\, -\infty}^{\infty} E_{mn} \operatorname{sinc}\left(\frac{2\pi m - \alpha}{2}\right) \operatorname{sinc}\left(\frac{2\pi n - \beta}{2}\right). \tag{8}$$

But $\operatorname{sinc} \pi(k - \ell) = 0$ for k, ℓ integers, $k \neq \ell$,

so

$$F(2\pi m, 2\pi n) = E_{mn}. \tag{9}$$

That is, the Fourier series coefficients exactly represent the values of the Fourier integral at harmonic frequencies.

2.12.12.3 Finite Sum Fourier Analysis

In the preceding section some of the features of two-dimensional Fourier integrals and series were discussed. Use was made of double integrals of $f(x, y)$ over a unit square. To allow numerical analysis by digital computers these integrals must be converted into finite sums of values of $f(x, y)$ at discrete points. This can be done by extending some of the techniques of finite-sum Fourier series analysis

from one dimension [1] to two dimensions.

Let $f(x, y)$ be specified at $2M$ equal-interval values of x and $2N$ equal-interval values of y inside the unit square, and be zero outside. This gives $4MN$ values

$$f(x_k, y_\ell),$$

where

$$x_k = \frac{(k - M)}{2M}, \quad k = 1, 2, \ldots, 2M,$$

$$y_\ell = \frac{(\ell - N)}{2N}, \quad \ell = 1, 2, \ldots, 2N.$$

If we again construct a double-periodic function $f_1(x, y)$ as in equation (4), equal to $f(x, y)$ at the $4MN$ points (x_k, y_ℓ), we can expand $f_1(x, y)$ in a Fourier series. In fact, a truncated Fourier series of $4MN$ coefficients will exactly equal $f_1(x, y)$ at the $4MN$ values of (x_k, y_ℓ). This truncated Fourier series is given by

$$f_1(x_k, y_\ell) = \sum_{m = 1-M}^{M} \sum_{n = 1-N}^{N} E_{mn} \, e^{+j2\pi(mx_k + ny_\ell)} \tag{10}$$

where

$$E_{mn} = \frac{1}{4MN} \sum_{k=1}^{2M} \sum_{\ell=1}^{2N} f_1(x_k, y_\ell) \, e^{-j2\pi(mx_k + ny_\ell)} \tag{11}$$

$$m = 1-M, 2-M, \ldots, M; \quad n = 1-N, 2-N, \ldots, N.$$

The above equations (10) and (11) can easily be established by applying the orthogonality property of the exponential function to the finite sum

$$\sum_{m = 1-M}^{M} \sum_{n = 1-N}^{N} e^{j2\pi x_k (m-s)} \; e^{j2\pi y_\ell (n-t)} = \begin{cases} 4MN & \text{for } m=s, \; n=t, \\ 0 & \text{otherwise.} \end{cases}$$

Again it can be shown that the Fourier integral $F(\alpha, \beta)$ of $f(x, y)$ and the Fourier series coefficients given by equation (11) are equal (at harmonic frequencies):

$$F(2\pi m, 2\pi n) = E_{mn}$$

for

$$m = 1-M, 2-M, \ldots, M; \quad n = 1-N, 2-N, \ldots, N.$$

The above equation (10) expresses the finite-sum Fourier series in exponential form. For computation purposes it is more convenient to use the sine-cosine form [3]

$$f_1(x_k, y_\ell) = \sum_{m=0}^{M} \sum_{n=0}^{N} \lambda_{mn} [A_{mn} \cos 2\pi m x_k \cos 2\pi n y_\ell + B_{mn} \cos 2\pi m x_k \sin 2\pi n y_\ell + C_{mn} \sin 2\pi m x_k \cos 2\pi n y_\ell + D_{mn} \sin 2\pi m x_k \sin 2\pi n y_\ell]; \quad (12)$$

where

$$\lambda_{oo} = \frac{1}{4}, \quad \lambda_{mo} = \lambda_{on} = \frac{1}{2},$$

$$\lambda_{mn} = 1 \text{ for } m > 0, \; n > 0;$$

and

$$A_{mn} = \frac{1}{MN} \sum_{k=1}^{2M} \sum_{\ell=1}^{2N} f_1(x_k, y_\ell) \cos 2\pi m x_k \cos 2\pi n y_\ell$$

$$B_{mn} = \frac{1}{MN} \sum_{k=1}^{2M} \sum_{\ell=1}^{2N} f_1(x_k, y_\ell) \cos 2\pi m x_k \sin 2\pi n y_\ell,$$

$$C_{mn} = \frac{1}{MN} \sum_{k=1}^{2M} \sum_{\ell=1}^{2N} f_1(x_k, y_\ell) \sin 2\pi m x_k \cos 2\pi n y_\ell,$$

$$D_{mn} = \frac{1}{MN} \sum_{k=1}^{2M} \sum_{\ell=1}^{2N} f_1(x_k, y_\ell) \sin 2\pi m x_k \sin 2\pi n y_\ell$$

where

$$m = 0, 1, \ldots, M; \; n = 0, 1, \ldots, N.$$

Some of the above coefficients, such as B_{mo}, need not be specified since $\sin n\pi = 0$. The total number of undetermined coefficients is $4MN$ as before.

The computation of the $4MN$ Fourier series coefficients requires on the order of $(MN)^2$ calculations. One way to reduce the number of calculations is to take advantage of the relations between harmonic values of the sine and cosine functions. There is a recursive relation [1] which, for the one-dimensional Fourier series computation, reduces

the number of calculations by 25%. However, the cost is successive roundoff errors (a sample test, run on ILLIAC II, of sin x, cos x for 200 values of x over the interval $(0, 2\pi)$, produced errors no greater than 10^{-8}). This recursive relation can be used by computing the two-dimensional Fourier coefficients as groups of one-dimensional coefficients, reducing the required number of calculations at the cost of a small error and an increase in temporary storage requirements.

References

[1] Hamming, R. W., Numerical Methods for Scientists and Engineers, McGraw-Hill Book Company, New York, 1962; Chapter 6 (pp. 67-80).

[2] O'Neill, E. L., Introduction to Statistical Optics, Addison-Wesley Publishing Company, 1963; Appendix A (pp. 157-165).

[3] Tolstov, G. P., Fourier Series, Prentice-Hall, 1962; Chapter 7 (pp. 173-198).

3. SOFTWARE SYSTEMS RESEARCH PROGRAMS

(This work is supported in part by Contract No. AT(11-1)-1469 of the Atomic Energy Commission and in part by the University of Illinois.)

This part describes work in progress on the Illinois Time-Sharing System which is currently being implemented on the ILLIAC II/PDP-7/IBM 1401 hardware.

Briefly the progress made this quarter includes the near completion of the planning of the final 64 console system and the implementation of some of it, the conversion of SOC to operate on Teletype consoles, the writing of a new desk calculator language TIPSY with more flexibility than SOC, the planning and writing of a console language LTLTRAN for eight consoles on the PDP-7 which will be used when the full system is unavailable and the preparation of a Provisional Time-Share System which will be used to debug the full system and bootstrap it onto the machine. At the time of writing (January 30) the provisional system is, in fact, operating. The PDP-7 was delivered and the channel is nearing completion.

People responsible for the sections in Part 3 are:

Gear, C. W., Richardson, F. K. Provisional Time-Share System and TIPSY

Fisher, R., Shepard, C. D. Command Processor, Scheduler, General System Organization

Greninger, L., Ellis, C., Lyon, D. Disk File Organization, File-by-Name, Sort-Merge

Dahm, M. Intape-Outtape Processor

Berg, Mary Ann. Loader, Library Search and Aquisition

Haas, M. LTLTRAN System

Otis, A. PDP-7 Console System

Willard, R., Bennett, D., Heimerdinger, W., Nuspl, S. Hardware System

Hassler, E. CLIC

C. W. Gear, Principal Investigator

3.1 Provisional Time-Share System

This system has been planned to allow itself to be updated from a console with the intention of thus being able to Bootstrap the full Time-Share System in a piece at a time. It also is intended to provide a minimal system for use by a few people until the new system is available. It currently will service three consoles in addition to the operator's console, this being the hardware limit. When the PDP-7 channel is available for general use, it is expected that this system will handle 8 to 10 trunks before saturating ILLIAC.

Operationally it leaves the present tape-to-tape batch system unchanged so that the work load can be handled as usual but it responds to a time-share interrupt signal by bringing in the provisional time-share command processor (BOOTS) which then can cause any task to be executed, including modifying the system for the right users!

The program is written in a modular manner such that new commands can readily be added as is evidenced by the fact that many of the commands were implemented by Messrs. Kelly and Fisher.

Within the framework of the system the TIPSY interpretive language processor is treated as a special case so that a very fast interactive desk calculator system in the JOSS spirit is available at the TTY consoles.

3.2 File-By-Name, Including Sort-Merge

Tentative plans had been made to make all logical records on the disk 10 words long (80 characters). This would have yielded 23 lines per physical track. This would have given an impressive simplification in systems programming and disk file usage. However, statistics from the BOOTS system have shown that this results in gross inefficiencies, in terms of both storage allocation and system overhead. By going to variable length records we can expect an average of 40-50 cards per track with a maximum of 63 and a proportional increase in the number of cards transmitted per SEEK. Two programs will be affected by the change--System File-By-Name (SYSFBN) and Sort-Merge.

3.2.1 SYSFNB

SYSFNB is a program which resides in the on-job monitor and which handles all I/O between users and the disk file. It takes care of blocking and unblocking logical records, linking physical records and overlapping I/O to the disk file. It also provides compatibility between programs running on the present system and the new system, and makes it unnecessary for the user to know that data is now going to and from the disk file instead of to and from the magnetic tapes, i.e. all of our present tape options will continue to be available through SYSFNB. In addition, provisions have been added which allow one to have simple dynamic buffer allocation at execution time. With these options one will be allowed to declare up to eight buffers, each buffer for input or output to one file.

3.2.2 Sort-Merge

Sort-Merge is a routine which will order files of arbitrary size. Two special techniques employed by the routine are block sorting during overlapped I/O and partially sorted file handing whereby only the changes to a file are sorted and then merged into the permanent file.

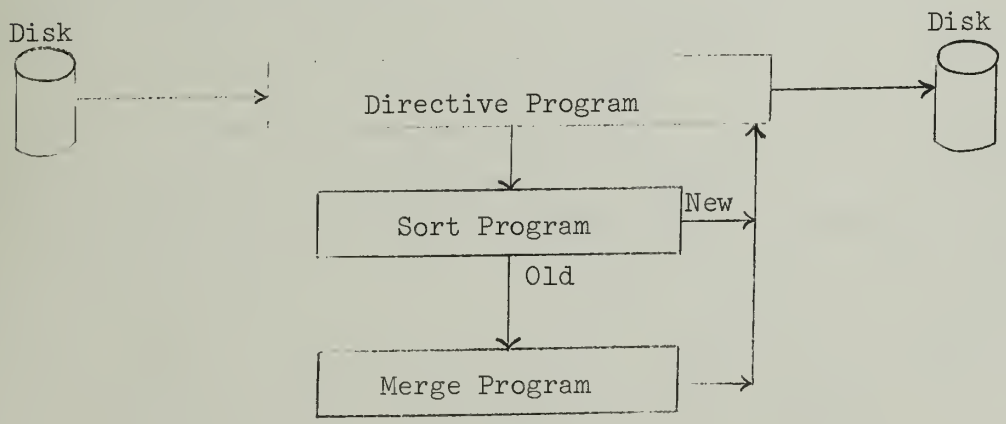
The Sort-Merge package is composed of three separate but interdependent programs.

A. Directive Program - controls overlapping of I/O with execution of B + C.

B. Sort Program - sorts one 256 word block of variable-length logical records.

C. Merge Program - merges any quantity of blocks together.

All three have been flow-charted and are being programmed.



3.3 PDP-7 Programming

LTLTRAN, a small subset of the FORTRAN language, is being programmed and will soon be available on the PDP for eight time-share consoles. In addition, the software interface between the PDP and the ILLIAC has been finalized, and the PDP programs which will handle 64 consoles simultaneously have been laid out in detail and are being programmed. Options to allow a paper tape to be input or output in either ASCII or in a non-decode 8-bit code mode have been included as well as options which allow the user to specify to the PDP such things as:

A. whether line numbers are to be supplied by the user or the PDP,

B. whether or not the line numbers associated with output are to be printed.

A test program for the ILLIAC is being programmed which should allow us to test the ILLIAC to PDP channels and all of the PDP software before the time-sharing system goes on ILLIAC.

3.3.1 PDP-7 Checkout

The PDP-7 was installed in early November. Extensive checking was done to uncover troubles while the Digital Equipment Corporation technical representative was available to fix them. This effort was particularly effective, as there were several troubles that would have been very difficult for us to fix.

Working copies of all the useful PDP-7 programs were generated, and the University of Illinois mnemonics were incorporated into the debugging and assembly program tapes.

Extensive tests were made on the remote console communication equipment, and several points of misunderstanding were cleared up. We have the software and hardware capability to handle Teletype, IBM 1050, and IBM 2741 consoles.

Familiarization checks were made on all the DEC supplied software. The PDP-7 routine library is still a going operation with 20 + routines in it now. A PDP-7 Trap Test was written, tested, and debugged by November. Planning was done for the PDP-7 satellite processor programs which will handle the remote consoles. More decisions need to be made in this area before programming can begin.

3.3.2 LTLTRAN

A revised specification of the language (see reference) was put out which indicated changes to make the console response more flexible and to conform to the ILLIAC II time-share system. More work was done to define the input line atomizing process and storage handling. The operation of the console teletype was worked out and documented. Furthermore, an interrupt program planning method was worked out for LTLTRAN and written up. The interrupt handling routine itself is programmed. The design report has been written and is now being reproduced.

3.4 Command Processor

It was tentatively decided some time ago that drum buffering would be used for I/O with the consoles. Basically, each console has one drum block (up to 60 console lines), where data is held until the block becomes full. For example, a program generating output to go to a console is swapped to the disk when the console's drum block fills up. Then output continues to the console without further reference to the disk until the drum block is emptied. This scheme has many advantages over sending lines directly to the disk. For example, such a user will get immediate response time on all output until the 50 or so lines have been transmitted to him. Further, by not going to the disk file for every line, we will save a total of about 50 SEEKS at an average of 150 ms per SEEK; whereas the time required to get a line from the drum block is less than 28 ms. When one is inputting from the console, lines are buffered onto the drum block until a command is received and the command processor brought in or until the drum block becomes full and the entire drum block is moved to the disk file. Once again the saving over sending the lines directly to the disk file is significant. The main disadvantage of this scheme is that the drum is significantly faster and more powerful a medium than is actually required. However, the next medium available is the disk file which is totally unsuited for line by line I/O.

There are two methods for changing programs in time-share systems, both of which are initiated by a LOAD ALPHA. In one case (e.g. BASIC) a copy of ALPHA is made and the user works with the copy. This had the advantage of not changing the original program in case the user changes his mind. The disadvantage occurs when the user, after making many changes, forgets to incorporate them into the original program. In the other case (e.g. BOOTS) the user works directly with the original program and the situation above is dualized.

From the system's point of view, creating copies is unreasonably time consuming; e.g. making a copy of the present monitor would require 14 seconds assuming nothing else needed either module during that time. The other method would probably result in the user creating his own copies.

The time-share system will not automatically create copies. In an attempt to free (keep) the user from creating copies, the changes to a file will not be incorporated until the user makes a specific (implicator explicit) request. Thus, a SCRAPC --scrap changes-- will be available to restore a file to its original condition (at load time).

3.5 Scheduler

The scheduler incorporates both the batch processing function and most of the sequencing of programs. There is one program (aside from the on-job monitor) which is not under scheduler control: the Command Processor (COMPRO). This is necessary because incoming data, particularly paper tape from consoles, must be serviced more often than the scheduler is in memory. The scheduler, in fact, will run in IA mode, so that it can be interrupted by COMPRO.

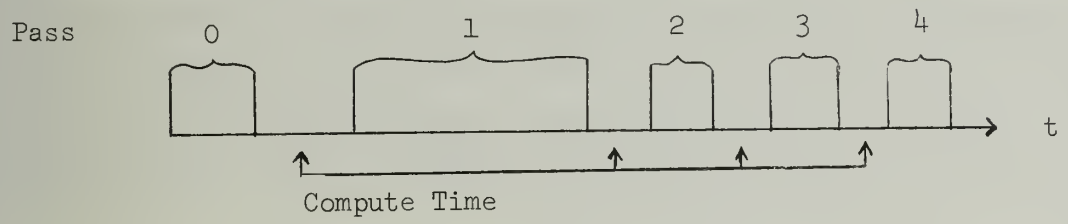
Each console will have a cylinder of the disk associated with it, where interactive core loads will be swapped. These core loads will include TIPSY programs, SOC programs, and programs for other interactive processors. Also included will be interactive programs written by the console user. Console users will also be able to send programs through the batch processor.

There are many considerations which will affect the response time at the consoles. Since it is most desirable to keep this response time to a minimum, much analysis of these considerations has been done. Consider, for example, the problem of NICAP and FORTRAN processing.

In the present system about 90% of the CPU time is concerned with NICAP assemblies and FORTRAN compilations. Although a non-trivial part of this time is spent in waiting on tapes to rewind (there are no such waits on the disk file), this still appears to be an area in which the overall system performance can be enhanced considerably. It was thought that NICAP and FORTRAN could be held on the disk file and either be overlapped to the drum by the system before they were needed or be overlapped in by previous passes. However, an analysis of the number of concurrent I/O activities pertaining to the disk file indicates

that there will simply be neither heads nor channels available for overlapping without conflicts. Further, upon looking at the disk file SEEK times, it becomes obvious that overlapping in the face of conflicts is considerably worse than no overlapping at all.

In view of the following time graph it appears equally absurd to bring these programs in linearly from the disk file.



3.6 INTAPE and OUTAPE Processors

An INTAPE processor which copies input tapes with batch jobs on them onto the disk file has been flow-charted and will soon be programmed. These jobs are put on the disk file in a format compatible with those jobs which originate from consoles. Thus, the scheduler and all other systems processors see only one type of job. This gives the scheduler the additional option of being able to pick out those batch jobs which fit into the job stream conveniently, rather than having to run the jobs sequentially as they were put on the input tape by the operator. The OUTAPE processor will then copy jobs run by the scheduler onto an output tape for subsequent processing by the peripheral computer. The OUTAPE processor will not be concerned with whether the job originated from batch or from a console. The INTAPE processor will allow users the capability of submitting card decks to be saved on the disk file under their I.D. numbers for later use in the time-sharing mode. Likewise one can have programs which were entered at the consoles punched and printed on the peripheral computer via the OUTAPE processor. Therefore the decision has been made that we will hold these two systems processors on the drum at all times. This will not be as expensive as it first appears due to the fact that FORTRAN passes one and two generate NICAP intermediate language--in fact, passes three and four of FORTRAN are simply passes three and four of NICAP. By taking advantage of this, both programs can be entirely held in 32 drum blocks (8K words).

3.7 Miscellaneous

I. SYSIO, the monitor program which currently allows users to use the magnetic tapes, has been removed from the monitor and made into a free-standing library program. In addition to freeing a considerable amount of monitor space, this will allow a facility for users to write scratch tapes in a format such that they can later be read as batch input tapes with all tape formatting automatically taken care of.

II. Research has been done on garbage collection (re-arranging programs and data on the disk file to reduce SEEK times) and the indications are that a garbage collector can significantly raise response time at the consoles. Plans are therefore being made to write such a program. It will include a disk-to-tape dump and tape-to-disk reload procedures.

III. Although not directly related to time-sharing, work was also done on making five-in-a-row available on consoles, analyzing two dimensional NIM, and programming a subroutine for the plotting of complex functions in order to obtain graphical locations of poles and zeros.

3.8 TIPSY

TIPSY is an interpretive processor for a simple desk calculator type of language. The user can type in up to five lines at a teletype which contain statements involving variables of one letter, constants and the usual FORTRAN subroutine SQRT, SIN, etc. A free format FOR statement more powerful than the FORTRAN DO statement is allowed in nests up to five deep and a READ statement is also provided. Printing occurs at every variable assignment but it can be inhibited. The capabilities of the language include simple table construction, simple data analysis (e.g. moments of observed data) in addition to the usual evaluation of complex expressions.

The program is written as a syntax directed interpreter with the result that it can easily be modified - and debugged! Using this approach it was written in 5 hours and debugged in 2 days.

3.9 CLIC

CLIC has been modified to some extent to adapt it to the general purpose time-sharing system. The present initial version of this system does not allow CLIC to operate without further modifications. Therefore, until the time-share system has evolved to a point where the disk file routines are close to their final form and the core allocation to the system is fixed no more effort will be expended on CLIC. At the time of this writing the compiler and loader system are operational with the exception of a few minor changes made recently. The CLIC supervisory system is in a rough state due to lack of knowledge of the form of systems communications to be required under the new time-share system. Also in a rough state are other items which communicate with the system such as the I/O units required and retrieval of subroutines from the system library.

It is anticipated that work will be resumed on CLIC as soon as the ILLIAC II time-share system is basically operational.

3.10 Time-Sharing Hardware

3.10.1 Disk File Engineering Channel

Further additions have been made to the Disk Diagnostic Tests to test the channel more completely, to allow more flexibility in control, and to output more meaningful results when errors do occur. The documentation of the tests is presently in progress.

The reformatting of portions of the disk to allow line transfers between the PDP-7 and the disk was studied and the results were presented in a memorandum [1]. The technique is very simple from a hardware point of view and represents the most natural way of interfacing the line oriented PDP-7 and block oriented ILLIAC II, while at the same time conserving core and drum space. A second memorandum, related to the first, describes an algorithm to be used to optimize disk transfers [2].

3.10.2 Core Interplay Channel Proposal

A study was made on the methods of connecting an existing core storage unit to Interplay, and its implications to the ILLIAC II system [3]. A number of channel configurations appear feasible; all featuring transfers programmed similar to and comparable or faster than those to the drum, with the

additional advantage of no access time delay. An additional option is an "EXCHANGE" command which exchanges portions of the primary and secondary core memories at roughly twice the drum transfer rate. A more advanced core channel would allow data to be transferred directly between the disk and the secondary core.

3.10.3 Satellite Processor Communications System

The PDP-7 satellite processor has been installed and connected to the completed ILLIAC II PDP-7 interface channels. After the interface hardware was connected to the PDP-7, the interface control logic was debugged and tested. Transfers to and from the PDP-7, using a variety of starting and ending conditions have been satisfactorily simulated under the control of PDP-7 programs and the programmable simulator for ILLIAC II. With the control logic debugged, work is progressing to resolve the remaining difficulties in transmitting the data signal levels between the PDP-7 and the interface channels. The PDP-7 has been used to control several remote console units through its Data Communication System, using direct connections and Dataphone links. ILLIAC II diagnostic test routines for the interface channels have been defined and partially written and debugged, leaving the PDP-7 test routines and the ILLIAC II time-shared test routines still to be written.

3.10.4 Computer Controlled Display System

A study has been made of the inherent problems in coping with interactive display consoles within a multi-user computer system. Specifications, resulting from this study, are being written for a Computer Controlled Display System for ILLIAC II. It is intended that this CCDS shall be capable of useful operations both as a free-standing system and as a display sub-system in the existing ILLIAC II computer complex.

Specifically, the system will include a small, general purpose digital computer; a special purpose digital controller, for handling display devices; and a high quality, large screen CRT display console, with a light pen as the primary input device.

It is hoped that, by suitable use of the local computing power contained within the CCDS, the volume of communications between the CCDS and the

Central Processor can be greatly reduced without seriously limiting the geometric powers of the system. For example, it should be possible for the general purpose processor to handle any required translations of displayed figures; however, the back-up computational power of ILLIAC II could be used to advantage for more complex operations.

3.11 Pertinent Publications for this Quarter Include:

Title	Source	Date
Organization of Active Disk Storage	P.M. 30	October 4, 1965
LTLTRAN on PDP-7 Preliminary Specification (Revised)	P.M. 23 Change 1	October 7, 1965
Report on the TTY Meeting, Comments, Paper Tape, etc.	P.M. 31	October 11, 1965
Core Loads and Interaction, Plotter Output, Progress in General	P.M. 32	October 11, 1965
PDP-7 Test Programs	P.M. 34	October 18, 1965
BØØTS	P.M. 33	October 18, 1965
PDP-7 to TTY Specifications	P.M. 35	October 19, 1965
Batch Restrictions	P.M. 36	October 19, 1965
Intape Outtape Processor, Tape SYSAUX	P.M. 37	October 21, 1965
Announcement	P.D. 0 (Program Description)	October 27, 1965
The Use of Disk by the October, 1965, BØØTS Processor	P.D. 1	October 28, 1965
Drum and High Core Allocation	P.M. 38	November 3, 1965
Scheduler	P.M. 39	November 3, 1965
PDP-7 Paper Tape Conversions	P.M. 40	November 4, 1965
Temporary BØØTS - System PDP-7 Communication	P.M. 41	November 5, 1965

Title	Source	Date
CØMPRØ (Console Command Processor)	P.M. 42	November 23, 1965
Interrupt Controlled I/O	P.M. 43	November 23, 1965
Notes on Sort-Merge Program	P.M. 44	November 23, 1965
Master ID Table and Dictionary Entries	P.M. 45	November 29, 1965

References

[1] Nuspl, S. J., Reformatting Portions of the Disk File to Handle Lines and Related Topics, IOHGM 27, December 16, 1965.

[2] Nuspl, S. J., An Algorithm for the Optimization of Seeks on the IBM 1301 Disk File, IOHGM 26, December 17, 1965.

[3] Nuspl, S. J., Some Proposals for Incorporating the IBM 7302 Core Memory into the ILLIAC II System, IOHGM 25, November 15, 1965.

4. ILLINOIS PATTERN RECOGNITION COMPUTER: ILLIAC III

(This work is supported in part jointly by the Atomic Energy Commission and the Advanced Research Projects Agency under Contract AT(11-1)-1018 of the Atomic Energy Commission.)

4.1 System Programming

The formal ILLIAC III Programming System Group, under the direction of Professor Manfred Paul, is responsible for the development of 4.1.1) the assembly language of the machine, 4.1.2) the generalized translator (preliminary version), and 4.1.3) the multiprogramming system of the computer complex.

In addition Professor Burton E. Squires, Jr. is investigating models of a generalized translator (compiler-compiler) of greater sophistication and modularity -- with an eye to a second generation generalized translator (in Section 4.1.4).

A third system programming component, supervised by Mr. Philip Merryman, is attempting to realize an experimental macro-programming system (Section 4.1.5).

4.1.1 IBAL Translator

A four-pass translator of the ILLIAC III Basic Assembly Language (IBAL) is in progress.

Pass I: Card images are read, identifiers truncated to 7 digits (and appropriate entries made in the symbol table), comments deleted, and other simplifying tasks compatible with maximum card read rate are performed.

Pass II: Syntactical errors are detected and diagnostics prepared. Where possible, the input string is backed up and the syntactic error patched, so that syntactic analysis can continue. Output of this pass is a syntactically error-free input string.

Pass III: Translation now proceeds assuming a syntactically error-free input string. Usual symbol table information

built up. Operand stack type of translation employed. Order of operands not permuted from order of occurrence in input string.

Pass IV: Forward addresses are filled in, diagnostics printed and a relocatable listing generated.

The present status of the translator is as follows: Passes I and III are nearly complete, Pass II is outlined, Pass IV is a relatively minor task but untouched at present. Recently however the data declaration capabilities of the IBAL language have been greatly extended, at a cost to the simplicity of the IBAL translator. To date these modifications to the language are not accommodated by the translator.

The IBAL translator is being written in ILLIAC II assembly language and will generate ILLIAC III machine code. A simulator for ILLIAC III on ILLIAC II is also contemplated.

4.1.2 Generalized Translator

A preliminary version of a generalized translator (compiler-compiler) is under design. In agreement with the basic organization of the previous study (Northcote and Steiner, DCS File Note 633), the translator breaks into a syntactic part and a semantic part.

The syntactic part will, unlike the Northcote and Steiner prototype, take direct Backus Normal Form input to define syntax of the source language to be translated. Detailed flow charts are now being prepared and will be issued as a file note in the spring.

The semantic part is of course much less well defined. The source language will be translated directly into IBAL in this preliminary translator. To simplify the translation it has been found convenient to reintroduce full block structure into the IBAL assembly language. The powerful macro-language aspects of IBAL also simplify the translation task.

4.1.3 Multiprogramming

Present work on the executive system for multiprogramming can be divided into four subareas:

i) Space and Time Allocation

ii) Segmentation

iii) I/O Handling

iv) Communication with Remote Consoles.

At present flow charts for the first two areas are being prepared, and the material appears tolerably well in hand. Area iii), I/O Handling, will be based upon the official ALGOL I/O recommendations (analogous to the earlier recommendations of Knuth) to be available in the spring. (Manfred Paul is a member of this ALGOL I/O recommendation committee).

Area iv), Communication with Remote Consoles, consists in part in the specification of the dialog communication language -- syntax and semantics. A preliminary document is planned by late spring. (Also see Section 4.1.5 below.)

4.1.4 Models for an Improved Generalized Translator

No uniform characterization of a generalized translator (compiler-compiler) yet exists in the literature. The following file note summarizes the models and status of work to date:

> Burton E. Squires, Jr. "A Review of the Status of Compiler-Compilers and Some Suggestions for Further Study", Department of Computer Science File Number 685, December 1, 1965.

Of particular interest is the problem of how to modularize the description of the source language, for example, so that minor changes in the source language do not propagate tidal transformations in the generated translator. A paper is in preparation which proposes a tentative structure for a (second-generation) generalized translator -- with this desired modularity.

4.1.5 A Macro-Programming System

The basic programming language of the ILLIAC III computer system (IBAL) is an outgrowth of a theoretical model of a computer-oriented programming language.[1] The authors of this model derived stimulus from the flow chart language of R. Narasimhan and J. Nievergelt,[2] the formal semantic language

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[1] McCormick, B. H., and J. A. Wilber, "A Computer-Oriented Language of Computation", Department of Computer Science Report, University of Illinois, in progress.

[2] Narasimhan, R. and J. Nievergelt, "On Computation in Computers and in Programming Languages , Department of Computer Science, University of Illinois, Urbana, Illinois, File No. 582, April 15, 1964.

of Jerome Feldman[3,4,5] and the macro programming system of Philip Merryman.[6] In particular, the direct introduction of imprimitive instructions into the instruction repertoire of the machine and the use of operand slashing stem from this latter work.

Merryman, working the past seven months at the University of Illinois, has been implementing his macro-programming system on the ILLIAC II Computer. The Illinois system is both generalizes and greatly extends in computational power the earlier prototype system. Because of the considerable similarities in language, it is anticipated that the dictionary, the dynamic storage allocation techniques of this implementation, as well as the editing procedures (adapted both for Teletype and CRT) can be later incorporated with appropriate modifications into the ILLIAC III programming system. Documentation on macro-programming the system is presently being prepared.

This work is of obvious importance to the development of large scale time-sharing systems, because integral to the system is the ability to use a large dictionary of macros (subroutines) which can be stored in read-only memory -- allowing multiple access without requiring memory protection.

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[3] Feldman, J.A., "A Formal Semantics for Computer-Oriented Languages", Doctoral Dissertation, Carnegie Institute of Technology, Pittsburgh, Pennsylvania, May, 1964.

[4] Northcote, R. S., "A Formal Semantics Language (FSL): To Facilitate the Computer Translation of Programming Languages", Department of Computer Science, University of Illinois, Urbana, Illinois, File No. 621, August, 1964.

[5] Northcote, R. S. and A. J. Steiner, "A Syntax Loader and Subscanner for a Compiler-Compiler", Department of Computer Science, University of Illinois, Urbana, Illinois, File No. 633, December 1, 1964.

[6] Personal Communication. This system was initially simulated in January 1965 on a CDC-140A computer at the Computation Center, New York University Medical School.

4.2 ILLIAC III Communication Net: General Introduction

4.2.1 General

The ILLIAC III Communication Net will attempt to provide remote users of the ILLIAC III Computer System with data and control communication both to the main frame of the ILLIAC III computer, and under conditions detailed below, to other users of the net.

The ILLIAC III Communication Net will allow three distinct modalities of information communication:

1) dataphone connection, over Illinois Bell Telephone lines
2) high speed digital character transmission, over 36 parallel coaxial cables, and
3) video communication, over low dispersion CCTV coaxial cables.

It is our intention that the dataphone connection serve remote Teletype sets and low data rate experimental equipment. Commercially purchased laboratory equipment to be used with the Communication Net should be provided by the manufacturer with direct dataphone output - and, where convenient, the added option of being able to drive a monitoring Teletype set.

There are however high data rate experimental equipments, scan/display systems, data acquisition systems and remote general purpose computers for which the channel capacity of telephone lines is prohibitively low. For these subsystems the ILLIAC III Communication Net will provide direct coaxial communication over 36 parallel coaxial cables. The digital interface, as seen by the user, is an extension of the standard IBM system/360 I/O Interface (abbreviated henceforth as X360 interface). Our inquiries have shown that most equipment can now be purchased in this interface--whether the equipment is of IBM or other manufacture.

Finally, to exploit the unique visual data processing capabilities of ILLIAC III, a video modality will be appended to the ILLIAC III Communication Net. The intention here is to allow CCTV cameras, monitors, video tape recorders, etc. to be used as remote video consoles of the ILLIAC III Computer System. Specifically this network comprises two (2) video signal lines (CCTV coaxial cable), three (3) digital control/synchronization lines (coaxial cable) and various standard camera/monitor remote control lines (twisted pair).

4.2.2 External Trunk Lines to ILLIAC III

We distinguish between external trunk lines of the communication net, which permit remote users direct multi-coaxial cable connection to ILLIAC III, and internal trunk lines, which service the ILLIAC III input/output equipment housed directly in the computer area. The computer system does not functionally distinguish between external and internal lines, except through program-controlled priority-of-service constraints. Each trunk line, external or internal, is assigned one ILLIAC III I/O Channel. There are five (5) channels associated with the five external trunk lines respectively, and eleven (11) channels associated with the internal trunks. These sixteen (16) trunks saturate the full sixteen (16) channel capacity of ILLIAC III.

4.2.2.1 Tentative External Cable Routes

Present plans are to provide four (4) external coaxial cable trunk lines as follows:

1) Digital Computer Laboratory, Engineering Research Laboratory, Physics Building, Materials Research Building, Coordinated Science Building
2) Digital Computer Laboratory, Mechanical Engineering Building, Morrill Hall (alternate: Burrill Hall), East Chemistry Building
3) Digital Computer Laboratory, Electrical Engineering Research Laboratory, Electrical Engineering Building, Lincoln Hall, Gregory Hall, Library
4) Digital Computer Laboratory, Civil Engineering (new building), Mercy Hospital.

4.2.2.2 Possible Later Extensions

Certain obvious extensions of this trunk system can be foreseen, but would not be laid until a possible Phase Two:

1) To trunk #2: East Chemistry Building, Bevier Hall, Animal Sciences Building, Turner Hall, Burnsides Research Laboratories, Veterinary Medicine Building, Zoonoses Laboratory

2) To trunk #3: Library, Education Building, Law Building

3) To trunk #4: Mercy Hospital, Carle Hospital

4) Additional trunk #5: Digital Computer Laboratory, Civil Engineering Hall, Mining and Metallurgy Laboratory, Noyes Laboratory of Chemistry, Chemistry Annex, Davenport Hall, Smith Memorial Music Hall.

Optimal mode of linkage to the proposed new Engineering Library, corner of Springfield and Goodwin, is presently unknown.

4.2.3 Internal Trunk Lines

The eleven (11) internal trunk lines of ILLIAC III are associated one-to-one with eleven (11) I/O channels of ILLIAC III. These trunks (channels) are divided into Backup Storage (4 channels), Scan/Display System (5 channels), and (in-house) Intermachine Communication (2 channels). Identification of each of these trunks is provided below.

4.2.3.1 Backup Storage Channels (4 channels)

Disk (2 small, 1 large)	(2 channels)
Magnetic Tape (8)	(2 channels)

4.2.3.2 Scan/Display System (4 channels)

High Resolution Scanners (8)	(2 channels)
Monitors (5)	(1 channel)
Xerox Printer	(1 channel)
Microwave Link, In-house Video-CCTV Cameras, Monitors, Video Tape Recorders, etc.	(1 channel)

4.2.3.3 Intermachine Communication (2 channels)

ILLIAC II, Proposed New Commercial Service Machine	(1 channel)
Engineering Test Console, Digital Microelectronics Laboratory (DML) Instrumentation	(1 channel)
Total	(11 channels)

4.2.4 Initial Installation Sites for Remote Video Consoles

The current ARPA support, under AEC Contract (11-1)-1018, provides for the immediate establishment of six (6) remote video consoles to exemplify the potential of the proposed video communication net. The essential and integral feature of this contract is to provide remote users with visual communication to a centralized pattern recognition computer (ILLIAC III) wherein tasks such as rearrangement, classification, idealization and statistical analysis of visual data can be performed.

Each console (and all will be identical) will include one CCTV camera, one 21" monitor and a Model 33 ASR Teletype set with dataphone connection. Two of these consoles will be placed in the Department of Computer Science; the other four (4) will be geographically dispersed.

We intend to supply by Fall 1966 one console to each of the following potential users:

1) DCS - for in-house document input
2) DCS - for microscope slide scanner
3) Physics - high energy physics data reduction
4) Burrill/Morrill Hall - Dr. Spiegelman's microbiology laboratory
5) Library - for library automation studies
6) Mercy Hospital - Dr. Williams' pathology laboratory.

4.2.5 Teletypewriter Equipment for Dataphone Connection with ILLIAC III

The ILLIAC III Communication Net will allow, as one of the three distinct modalities of information interchange, direct dataphone connection over Illinois Bell Telephone lines. Aside from the immediate transfer of experimental data at low transmission rates, the predominant use of dataphone connections to ILLIAC III will be to service Teletype remote consoles.

In the interest of uniformity two largely equivalent Teletype remote consoles are specified for use in the ILLIAC III Communication Net.[1] The first set can be rented from Illinois Bell Telephone, the second set can be purchased from the Teletype Corporation and augmented by a dataphone connection rented from Illinois Bell Telephone.

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[1] See Divilbiss, J. L. and B. H. McCormick, "Specifications for Teletypewriter Consoles for Use with the ILLIAC III Communication Net", Department of Computer Science File Note 550-65, February 7, 1966.

All consoles employ a subset of the American Standard Code for Information Interchange (ASCII). This code is used uniformly with all ILLIAC III I/O devices.

The preferred consoles are essentially Model ASR33 Teletype Automatic Send-Receive Sets in the "Switched Network Version". With recommended modifications these sets incorporate the "Answer-Back", "Pin-Feed" and "Form Out" features. But of greater technical importance the sets purchased direct from Teletype are provided with parity.

4.2.6 Description of High Speed Digital Character Transmission Interface

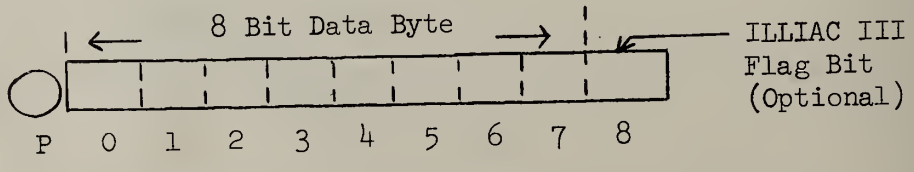
High speed information transmission, parallel by character, between ILLIAC III and remote attached devices is governed in format of buses, mode of operation (device addressing, commands, sequence controls, etc.) and physical signal levels as specified by the conventions of the IBM System/360 I/O Interface - as extended below.

Description of this interface will be found in literature supplied by IBM to original equipment manufactures (so-called OEM manual). The appropriate reference is:

IBM Systems Reference Library
IBM System/360 I/O Interface - Channel to Control Unit
Original Equipment Manufacture's Information
File No. S/360-19
Form A22-6843-1[+].

This interface is extended (hence X360) in the ILLIAC III Computer System in two regards:

1) Nine bit character transmission is permitted. Accordingly the INBUS and the OUTBUS are each augmented by an additional bus line P8. Accordingly a (10 bit) bus character looks like (P = parity):



[+]The last integer, i.e. "1", indicates revision number of OEM manual. We will attempt to keep compatible with current revision.

As before, the byte must always have odd parity. For devices not employing the 9th (flag) bit in each byte (i.e. IBM System/360 equipment), line P8 can be left as an open input (cable logical zero).

2) In the normal IBM 360 interface all transmission is interlocked with corresponding response signals, permitting system input and output operations that are not dependent upon circuit speed. However, this strict reply-back arrangement can restrict data transmission to approximately 10 per cent of maximum channel capacity -- because of the propagation delays of these replies in the extensive 36-line coaxial cable trunk system. Accordingly we will permit stream transmission, i.e. transmission of a prespecified number of data bytes at a prearranged clocked rate. Dummy replies will be generated by the communication net -- so that as seen by the attached device the transmission is, apart from the prearranged byte transmission frequency, indistinguishable from a local channel connection operating in burst mode. Only (multibyte) data transmission can operate in this stream transmission mode; initial device selection and the ending procedure are fully interlocked with reply-back signals.

4.2.7 Description of Video Interface

Video transmission between ILLIAC III and remote video consoles, as well as between one video console and another, is governed in format of lines, mode of operation (device addressing, commands, sequence controls, etc.) and physical signal levels as specified by the conventions of the ILLIAC III video interface.

These video interface standards can be understood by analogy with the X360 interface conventions. The video cable contains an OUTBUS (a low dispersion coaxial cable for the outgoing video signal + twisted pair lines for outgoing camera/monitor remote control signals), an INBUS (a low dispersion coaxial cable for the incoming video signal + twisted pair lines for incoming camera/monitor remote control signals), a single outgoing control line OUTCNTL (digital-quality coaxial cable), a single incoming control line INCNTL (digital-quality coaxial cable),

and a synchronization line SYNC (digital-quality cable). Basically the control lines, OUTCNTL and INCNTL, mimic in bit serial format the multiple control lines of the X360 interface.

The video interface assumes that time slots of 1/60th second are assigned a given video console by the communication net supervisory program. Initial device selection and the ending procedure are permitted only at the initiation and termination respectively of a time slot and employ the INCNTL and OUTCNTL lines exclusively. Accordingly the video interface assumes a data transmission sequence (over INBUS or OUTBUS lines) which is an integral multiple of 1/60 sec (approximately). This is the EIA-specified field time for 525-line broadcast TV.

Approximately 14 twisted pair conductors are assigned the low frequency camera/monitor control functions: focus, pan, tilt, zoom lens control, etc. The detailed assignment of these lines will follow commercial TV practice.

4.2.8 Use of High Resolution Closed-Circuit TV with ILLIAC III

Recently several high resolution closed-circuit TV systems (Granger Associates, Fairchild, etc.) have appeared on the market. These systems produce picture tube images with more than four times the detail that can be seen on conventional 525-line closed-circuit displays. For example detailed documents such as typewritten pages, maps, microscope (light and electron) images, and fine-line photographs can be transmitted effectively.

The resolving power of these systems is due basically to a very wide video bandwidth: 24-30 MC instead of the 8 MC bandwidth commonly employed in closed-circuit television. This larger bandwidth plays havoc however with potential ILLIAC III applications in three regards:

1) The video communication net would require numerous repeaters and signal equalization,
2) direct video tape or buffering of the video signal is not feasible at reasonable cost, and
3) the DAC and ADC byte conversion rate at an ILLIAC III channel becomes excessive.

Accordingly the following compromise has been adopted. All high resolution cameras (i.e. above the standard 525-line systems) must be provided

with both the high bandwidth 30 frames/sec scan--for direct monitoring at the remote station, and a slow 7 1/2 or 15 frames/sec scan--for transmission through the Communication Net.

Initial remote video consoles will be provided with cameras having a 1029 line scan and 30 MC video bandwidth. (In the Granger Associates unit this corresponds to a vertical resolution of 720 lines and a horizontal resolution of 850 lines). These cameras will be scan at either 60 fields per second with 2:1 positive interlace to produce 30 frames per second (for direct monitoring), or, upon remote selection, a slow scan option of 15 fields per second with the same 2:1 interlace. In this latter mode of operation the camera requires approximately 8 MC video bandwidth.

The characteristic mode of operation under this slow scan compromise might be as follows:

1) Remote user equipment is adjusted and locally monitored using the full 30 MC bandwidth requirements of a 30 frame/sec high resolution system.
2) Transmission of an image to the computer, by momentarily dropping down to slow scan, scarcely titulates the image at the neighboring monitor. Total transmission time is less than 1/10th second.
3) Replies, both results and diagnostic information, are transmitted at 525-line resolution. Programming can be used to arrange the response in palatable form, using if necessary a sequence of 525-line images. Alternatively 525-line labeling images can be interwoven with the original high resolution (and high bandwidth) image at the monitor. By these expedients the bandwidth requirements of the video communication network is kept to 8 MC or less, and such that with moderate loss of resolution both video tape and microwave links can be used in the system.

5. NUMERICAL METHODS, COMPUTER ARITHMETIC AND ARTIFICIAL LANGUAGES

(Supported in part by the National Science Foundation under Grant No. NSF-GP-4636.)

5.1 Theory of Multiplier Recoding

An extension to the binary theory of multiplier recoding was discovered during the quarter. To place the extension to the theory in proper perspective, a description of the historical development is necessary:

(1) If binary digital values after recoding are restricted to the redundant set -1, 0, or +1, the recoding is completely characterized by the choice of two arbitrary Boolean functions.

(2) If each recoded digit of a binary number x is the negative of the corresponding recoded digit of -x when the same recoding is applied to both x and -x, then the recoding is characterized by the choice of a single Boolean function.

(3) Recoding of a number x may be achieved by the artificial procedure of multiplying x by d, and by then dividing the product xd by d to form a quotient x', if each digit of x' is in redundant form. For the binary SRT division, each quotient digit has one of the values -1, 0, or +1, and the magnitude of each quotient digit is determined by comparing the magnitude of the partial remainder with the comparison constant $\frac{1}{2}$. The recoding of x into x' is then a function of the value of d.

(4) The SRT division $x' = \frac{xd}{d}$ with comparison constant $\frac{1}{2}$ may be scaled by multiplying the divisor, the comparison constant, and the dividend (and hence all partial remainders) by the factor $z = \frac{1}{2d}$. If the minimum precision required to represent z is k binary digits, then the single Boolean function f_i characterizing the recoding of x into x' is a function of the k digits x_{i+j} (j= 1, 2, ..., k) of x. A unique binary fraction can be generated for each minterm of the canonical expansion of f_i by associating 0's with

complemented variables and 1's with uncomplemented variables in the usual way, and forming the weighted sum with weight 2^{-j} associated with digit x_{i+j}. The canonical expansion of f_i is then found by excluding all minterms with values less than z, and including all minterms with values greater than or equal to z. The results of extensive studies of the statistical properties of the SRT division can be applied to the resultant family of recodings and indicate, for example, that the probability of a zero, after recoding, is z for $0 \leq z < \frac{2}{3}$, and is $\frac{2}{3}$ for $\frac{2}{3} < z < \frac{5}{6}$, and decreases in a complicated nonmonotonic manner from $\frac{2}{3}$ to $\frac{1}{2}$ for $\frac{5}{6} \leq z \leq 1$.

(5) A transformation of the family of scaled SRT recodings is possible; the effect of the transformation is to replace the binary digital pair 10, by the equivalent pair 02. The effect of the transformation on the statistical properties can be determined.

Thus the properties of families of recodings which are applied serially, most significant digit first, are well understood. The extension to the theory discovered during the past quarter is that there is a one-to-one correspondence between a family of serial recodings, applied least significant digit first, and the transformed family of SRT recodings which are applied serially, most significant digit first. The correspondence involves replacement of each y_{i+j} of the transformation of f_i by y_{i-j}, hence a corresponding pair of recodings are, in general, not identical. The statistical properties, however, are the same for each recoding of a corresponding pair. (J. E. Robertson)

5.2 Relationship Between Arithmetic Structure and Digital Probabilities

A statistical analysis of certain members of the class of "totally parallel" digital adders has been undertaken. This class of adders forms the sum $s = x + y = \sum_i s_i\, r^{-i}$ (or difference) of two numbers $x = \sum_i x_i\, r^{-i}$, $y = \sum_i y_i\, r^{-i}$ which are in signed digit representation according to the following algorithm.

$$x_i + y_i = r\, t_{i-1} + w_i$$

$$s_i = w_i + t_i$$

As indicated by these equations, the ith sum digit, s_i, is completely determined by the four input digits x_i, x_{i+1}, y_i, and y_{i+1}. In other words, carries (or borrows) propagate no further than one stage (digital position) to the left. The sum or difference formed by the adders are in the same signed-digit representation as the input numbers x and y.

The primary objectives of the investigation will be to:

(1) Determine the probability distribution of the sum digits as a function of the distribution of the augend and addend digits.

(2) Find the steady state distribution of the sum. The steady state distribution, if it exists, is defined to be that distribution of the augend which causes the sum to have the same distribution.

(3) Determine the recoding activity of a particular adder. In other words, for particular codings of the augend and addend determine the resultant coding of the sum.

Each adder of this class is a subtracter as well since $x - y = (x + (-y) = x + \sum_i (-y_i)\, r^{-i}$ and since the inputs to each stage may be negative as well as positive.

A particular subtracter, which is essentially equivalent to a stored borrow subtracter, has been examined. It forms the difference $d = \sum_i d_i\, 2^{-i}$, $\{d_i\} = \{\bar{1}, 0, 1\}$, of the minuend $x = \sum_i x_i\, 2^{-i}$, $\{x_i\} = \{\bar{1}, 0, 1\}$, and the subtrahend $y = \sum y_i\, 2^{-i}$, $\{y_i\} = \{0, 1\}$. The probability distribution of the digits, d_i, of the difference is given by:

$$p(d_i = \bar{1}) = \frac{1}{2}\, p(x_i = \bar{1}) + \frac{1}{4}\, p(x_i = 0)$$

$$p(d_i = 0) = \frac{1}{2}$$

$$p(d_i = 1) = \frac{1}{2}\, p(x_i = 1) + \frac{1}{4}\, p(x_i = 0)$$

with a steady state distribution of

$$2p(d_i = \bar{1}) = 2p(d_i = 1) = p(d_i = 0) = \frac{1}{2} \quad .$$ (F. Rohatsch)

5.3 Autonomous Arithmetic Unit Structures

Avizienis Signed Digit Number Representations[1] were investigated for application to the limited connection arithmetic unit since they have the property of limited dependence of sum digits. The value of a given digital position of a representation of the sum of two operands is a function of the values of the corresponding digital positions of the operands and the values of the digital positions next lower in value. That is, if numbers are represented:

$$Z = \sum_i z_i\, y^{-i}$$

where

$$i,\ z_i,\ M,\ N, \&\ L_z$$

are integers such that

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(1) Avizienis, A., "Signed Digit Number Representations for Fast Parallel Arithmetic," IRE Transactions on Electronic Computers, Vol. EC-10, No. 3, September 1961, pp. 389-400. See also Department of Computer Science Report No. 101.

$$M < i < N$$

$$0 \leq |Z_i| \leq L_Z$$

$$\frac{(r+1)}{2} \leq L_Z \leq r - 1 ,$$

then for N and A, $\exists S \ni s_i = f(n_i, a_i, n_{i+1}, a_{i+1})$ and $S = N + A$.

If one investigates the additional properties required to perform operations of the form

$$S_i = A_i + k_i N_i , \qquad k \text{ integer}, \ 0 \leq |k_i| \leq K$$

$$A_{i+1} = r \cdot S_i$$

which are necessary for implementing multiplication and division without subsidiary registers or multiple forming circuits, one discovers that two conditions be met in order to make K large enough to be useful.

(1) $L_s = r - 1$ and L_N be minimum

(2) The radix be larger than 7 for odd radices, larger than 10 for even radices.

Under these circumstances $K = \frac{r}{2} + 1$ for even radices and $K = \frac{r+1}{2}$ for odd radices. This implies that if the k's are quotient digits or multiplier digits, that if the multiplier is in anything but minimal redundancy representation it must be converted. Since products would be in maximal redundancy form [condition 1], this is inevitable, and implying that all multiplications must be preceded by redundancy reduction steps of both the multiplicand [which would be N in the nomenclature above] and multiplier [K]. Division must be proceeded by a redundancy reduction of the divisor [N] and yields minimum redundancy quotients [-K]. The number of digital positions of the partial remainder [A] which must be examined in large due to maximal redundancy of the partial remainder.

Because of the necessity of redundancy reduction steps and the delay anticipated due to the number of digital positions of the partial remainder which must be examined to determine each quotient digit, modified signed digit representations, where the functional dependence is increased to include next nearest neighbor digits [to the right] in addition to nearest neighbors, are presently being investigated. (M. Pisterzi)

5.4 Hydrodynamics

The doctoral dissertation by T. S. Shao entitled "Numerical Solution of Plane Viscous Shock Reflections," prepared under the guidance of Professor C. W. Gear, was completed September 30, 1965, and distributed as Report No. 190. This work was partially supported by the NSF Grant. A summary of this research follows.

When a plane shock strikes a smooth rigid wall with a sufficiently large angle of incidence, it gives rise to an irregular type of reflection called Mach reflection, characterized by the intersection of three shocks at a point detached from the wall. The classical approach involves solution of the integral form of the equations of motion everywhere except at the shock (assumed zero thickness), and solution of the Rankine-Hugoniot equations for the discontinuities across the shock itself. Classical solutions to the Mach reflection problem for weak incident shocks have not been very successful, and one of the points of this research was to try to find out whether the fact that viscosity is neglected in this case was a principal reason for these inaccurate solutions. The main part of the dissertation consists of a method for numerically integrating the Navier-Stokes equations for the above problem assuming the viscosity coefficient is constant and that the heat conduction terms may be neglected. A mixed Lagrangian-Eulerian system similar to Harlow's Particle-in-cell method was used. Numerical results indicated close agreement with experiment, and when the viscosity term was dropped the solutions became very inaccurate. The method of solution is still very time-consuming, so efficiency should be a fruitful area of further study. (T. S. Shao)

5.5 Numerical Analysis

In the solution of systems of linear equations arising, for example, from the discretization of elliptic partial differential equations, two commonly used methods are point and block successive over-relaxation using the same extrapolation factor at each point (or block) of the array. Preliminary experiments show that a considerable increase in the rate of convergence may be obtained by using a set of extrapolation factors -- a different one for every mesh point. For point SOR the best choice calls for factors near one near boundary points and progressively larger factors toward the center of the array. Contrary to experience with one uniform factor, the eigenvalues of the iteration matrix appear to be all real for the optimum choice of factors. This considerably complicates the analysis of the general case and makes it very unlikely that formulas for the optimum factors can be obtained.

One could proceed in one of two ways: either develop ad hoc rules for selection of good ratherthan best factors, or consider a restricted class of factors and optimize subject to the restrictions.

An example of the second approach is to analyse the point problem in one dimension and extend the results to block methods in two or more dimensions, using always only a one-dimensional array of extrapolation factors. In one dimension it was also possible to solve the more general problem of minimizing the spectral norm of the k-th power of the iteration matrix yielding a method having the best guaranteed improvement after k steps. For n equations and n steps the best iteration matrix is nilpotent. In this case one may relate one iteration with Gaussian elimination, and the back substitution process is equivalent to a three term recurrence relation between successive iterates going backwards over the point set. In other words a forward and backward iteration exists which yields the exact answer in two steps.

Preliminary experiments indicate that one can apply these techniques to block iterative methods in two dimensions, and that they may have certain other advantages, such as allowing one to get accurate values at certain selected points in a very few iterations, or have a monotone error behavior. (D. B. Gillies, Principal Investigator)

6. ILLIAC II SERVICE, USE, AND PROGRAM DEVELOPMENT

(This work is supported in part by Contract No. AT(11-1)-1469 of the Atomic Energy Commission and in part by the University of Illinois.)

6.1 ILLIAC II Program Development

6.1.1 System Program Development

Refinements and some minor changes to the system have occurred this quarter. The System Tape Update Program was further revised and modified in order to allow it to be used as a normal batch processing job during regular code check. This is now in use for both the time-share and non-time-share systems.

The BOOTS system program was taken off tape and now resides on the disk file. This has released one tape unit for the batch processor users. However, the input and output tapes for console runs still require the use of two tape units.

A tape copy-compare program was written for the BOOTS system. This has not been debugged as yet. Instead of the present system which requires a special case bootstrap and a special program in order to copy and compare tapes (and thus complete a system update), this new program will provide the ability to copy tapes during the regularly scheduled time-share periods.

Due to many factors, it was decided to abandon the IBM 1050's and use only teletypes for the time-share consoles. Teletypes have also replaced the on-line typewriters which serviced the machine operator's stations. Thus, there was a change involved in making SOC run from the teletype and in transposing monitor's typewriter program into one for the teletype. A portion of the off-line monitor which sends disk error messages to the typewriter is being recoded for teletype output in line with the change over.

The time-accounting in the time-share system was rewritten and is greatly improved. The initial time-share system is now running smoothly and its operation is straight forward.

SYSAUX for the disk files has been rewritten to include further additions and to correct existing faults. Other changes remain to be programmed and code-checked.

The use of the ILLIAC II consulting service has increased manyfold this past quarter. Principal problems have been in the area of FORTRAN, the CalComp plotter, and library subroutines.

The sections of Part 6 are the responsibility of the following people:

Software System

Aaron, J. Supervision

Brower, E. Fortran Compiler

Slivinski, T. Nicap and Macro

Watkins, J., Chase, S., Neuhaus, P. Library

Operations and Maintenance

Carter, C. Supervision

Huffman, W., Lopeman, H. Records

Kerkering, T. CalComp Plotter

Conroy, D., Holland, L., Huszar, G., Rohatsch, F. Test Programming

C. W. Gear, Project Director

6.1.2 FORTRAN, the ILLIAC II Compiler

Several errors dealing with the handling of fixed point variables and Hollerith constants have been corrected and the FORTRAN compiler has been updated. Notices have been posted indicating the details of these corrections.

Write-ups and flow charts are being made for the control transfers, the DIMENSION and the EQUIVALENCE sections of the FORTRAN compiler. A change is also being made in the organization of the FORTRAN compiler to enable use of the NICAP pseudo order, COMMON, and to make future updates and the checking of the newly generated system tapes a category I type job.

Certain errors which have recently been brought to attention are being solved. The input/output of a sequence of more than ten fixed point variables will soon be handled correctly. Other corrections are being made to fix the exponentiation on an indexed variable, the EQUIVALENCE of variables to elements of an array in an order other than from first to last, and the EQUIVALENCE-ing of two or more names to different elements in an array.

6.1.3 NICAP, the ILLIAC II Assembler, and the NICAP MACRO PREPASS

NICAP was modified to allow inclusion of the basic MACRO package into the system. Primarily, this entailed changing PASS I of the assembler to allow the processed MACRO program as input instead of a source deck.

Due to sundry technical difficulties, the MACRO PREPASS was not incorporated into the system this quarter; hopefully, it will be in operation early in the next quarter.

Requirements on NICAP for the future Time-Sharing system were enumerated and some planning was done to make their implementation possible.

In the next quarter, some long-standing but minor NICAP problems will be corrected.

6.1.4 LIBRARY, ILLIAC II

Much time was spent preparing for a Library Tape update. Before any program is added to the tape, sequenced source decks, binary decks, and program listings must be prepared. When the present update is completed, the following will be done:

(1) These new routines will have been added to the library:

CalComp Plotter Subroutines:

- CCP3NR, CCP5AX, CCP8DL, CCP9DN — explained previously
- CP11EL - draws an ellipse or circle or any part thereof
- CP15FN - plots the user's function which is in a subroutine

- DVDF - a FORTRAN compatible version of DVDF1
- FLGUN - a FORTRAN compatible version of LGUN
- LAG - a FORTRAN compatible version of LAG6
- FATAN - a FORTRAN compatible arctangent subroutine which returns values of the arctangent between $-\pi$ and $+\pi$ so as to be in the correct quadrant.
- FETTER - a FORTRAN entry to LETTER.
- LETTER, ALETER - a modification of PRINT which allows the writing of BCD strings of characters on the CalComp Plotter

(2) The following subroutines will have been replaced:

- CCP1PL - a CalComp Plotter routine which among other things will only allow use of a 10 inch y-axis
- COSH1, SINH1, GQU1 - now have entry points for FORTRAN users
- SLQ1, EXP1, XYZPLT, PRINT, CP10GD, CCP2SY - had errors corrected

(3) All entry names for the subroutines CCP1PL and CCP2SY which do <u>not</u> begin with "CCP" will have been eliminated.

There now exist two versions of CCP1PL. One of these will not be on the Library Tape and will be available only to those users who obtain special permission. This version allows the use of 29-inch wide plotter paper and allows the user to change not only the limit on the length of the x-axis, but the length of the y-axis as well. A write-up for the new version of CCP1PL is ready to be duplicated.

MATINV, a University of Illinois IBM-7094 FORTRAN routine, is being translated into NICAP. This routine solves systems of simultaneous linear equations and inverts the coefficient matrix in the process. RØM, a NICAP integration routine that uses Romberg's method, is being tested and information is being obtained for a Library write-up.

A polynomial root subroutine which finds the n complex roots of an nth order polynomial with either real or complex coefficients has been revised to meet the requirements of the present system. The subroutine uses Muller's method to determine the roots. Related subroutines also available are a complex multiply, a complex divide, and a complex square root program. The root subroutine has both FORTRAN and NICAP entries. For each of the three other NICAP subroutines there exists a subroutine which has a FORTRAN compatible entry. These subroutines will be on the ILLIAC Library Tape and write-ups will be available.

The following literature was distributed during the quarter:

Title	Source	Date
Digital Incremental Plotter Subroutines (DIPS) (Basic information and introduction to plotter subroutines)	Provisional Library Subroutine Write-Up	November 9, 1965
Library Tape Change	Memorandum	December 8, 1965
Bode Plot Evaluation	Provisional Subroutine Write-Up	December 8, 1965

6.1.5 CalComp, Digital Incremental Plotter

A user's group for the CalComp was formed in order to prevent duplication of effort in the generation of subroutines and to pass on useful graphing techniques. The group was organized and set up a scheme for disseminating literature. Subroutine write-ups and other informative literature were gathered into a package which was distributed to all members. Several meetings have been held and the group's size is increasing rapidly. The noticeable accomplishments of this group thus far have been to spread knowledge of the plotter, to create more interest in it, and to make suggestions to the System Group for its proper use and handling.

Due to the large difference in the total cost of large versus the small plotter paper, users were asked to scale all output down. All normal plot jobs are now run on the small paper; special permission and a special production run are required for the larger size plots.

In order to maintain compatibility with the IBM 7094, conventions were set up for CalComp subroutines. The basic routines for the plotter have been written and will soon be obtainable from the ILLIAC II Library Tape.

Pertinent publications were:

Title	Source	Date
Plotter Paper Use	Memorandum	September 29, 1965
Formation of CalComp User's Group	Memorandum	October 11, 1965
Results of Meeting Held October 19	Memorandum	October 22, 1965
Meeting of Group (Notice and schedule of December meeting)	Memorandum	December 6, 1965
Meeting Held December 14, 1965	Memorandum	December 20, 1965
Schedule of Plotter Availability	Memorandum	December 29, 1965

6.2 Engineering Test Programming

6.2.1 Research

The search for a more effective diagnostic approach to the arithmetic subsystem of ILLIAC II is being conducted. Recent machine malfunctions have escaped detection by "test" programs and extensive down-time has been necessary to locate faulty data paths caused by component failure. It is felt that the proper choice of data and control flow can detect errors within the arithmetic subsystem and provide the maintenance personnel with a pointer to the defective area, section, or bit. The study will be extended to control paths as more information is gained.

6.2.2 Test Routines

Some of the "System II" engineering test routines have been rewritten in NICAP. These test the A.C. orders LFR, SFR, CAM, ADM, SBM, ATN, SFN, CRM, NDM and the D.C. orders STF, SIF, SIA, SRS, SAL, STU.

New routines are being written which test the following A.C. orders LIN, ØRB, LDM, EQM, CSM, NAM, SBM, ØRM, EØM, CAM, ANM, ADM.

6.2.3 AEC

The AEC system was written on the disk file in December. The bootstrap program which brings AEC into core is the same as before and resides on the drum. A sum-check of AEC is performed when it is brought into core; failure would indicate a hardware failure.

6.3 CalComp Hardware Aspects

The use of the CalComp Plotter has been increasing as the knowledge of its existence and its possibilities become more widely known. Its use in the month of October increased 50% over its use in September; November was about the same as October; however, use in December increased 300% over that in November.

There was an idea that the plotter tape unit was damaging the tape. Therefore, a test was begun in order to see if this was a fact. So far, no evidence of any such damage has been apparent.

As the use of the plotter increases, the problem of proper operation also increases. It is now apparent that some form of close operator control will be necessary for effective use of the plotter.

6.4 Engineering Maintenance

6.4.1 ILLIAC II Engineering Log Summary - October, November, December, 1965

Error Analysis - ILLIAC II	October	November	December	Totals
1301A	1			1
1401			1	1
1402		3		3
1403	1			1
1414A	19	1		20
1414B	1			1
Advanced Control			2	2
Console	2			2
Air Conditioning			1	1
Core 0	1	5	1	7
Core 1	2	2		4
D/A Converter	1			1
Delayed Control		1		1
Disk Files		1		1
Drum	1	2		3
Flow Gating		2		2
Interrupt			1	1
*Interlock		3		3
Interplay			1	1
Human Errors	2	2	4	8
**Maintenance			4	4
MAU		5		5
MSRDP	1			1
Logic Errors	3			3
Power Supplies	19	11	8	38
Programming Errors	2			2
Reader			1	1
Selectric Typewriters	12			12

*Errors occurred on Brower's program which turned out to be a logic error in interlock.

**These errors occurred apparently due to turning off power for about three hours in order to clean power supply room.

Error Analysis - ILLIAC II	October	November	December	Totals
Special Registers	1			1
Tape Units	9	11	5	25
Unknown	1	3	1	5
	79	52	30	161

6.4.2 Equipment Requiring Servicing

6.4.2.1 IBM Equipment Requiring Services of Customer Engineer

Tape Units	October	November	December	Total
J	1	1	1	3
G	1			1
H	1			1
F		1	1	2
C		1		1
A		2		2
E			1	1
Selectric Typewriters	4			4
1401	1	3	1	5
1402	2	2	1	5
1403	2		5	7
1301A		1		1
1301B		1		1
	12	12	10	34

6.4.2.2 Off-Line Equipment Requiring Repairs

Type	Name	October	November	December	Total
026	Key Punches	6	3	5	14
082	Sorter		1		1
514	Reproducer		1	2	3
557	Interpreter			1	1
026	Key Punch (Interpreter)			2	2
33	Teletype (KSR)	2	4	2	8
1056	Card Reader	1			1

Type	Name	October	November	December	Total
564	CalComp Plotter	3	5	7	15
670	CalComp Tape Unit			2	2
	Total	12	14	21	47

6.4.3 Scheduled Diagnostic Engineering

A. Maintenance

a.	Checking transistors	20 hours
b.	Marginal DC voltage tests	26 hours
c.	Component replacement tests	4 hours
	(trying new transistors to replace obsolete transistors)	
d.	Checking out spare chassis	6 hours
e.	Cleaning power supply room	16 hours*
	(*resulted in machine malfunctions)	
f.	Replating card contacts	6 hours
	Total	78 hours

B. Component Failures

a.	Transistors in main machine (main frame, core 1, interplay, drum and power supplies)		
	main machine		40,121
	power supplies		3,592
		Total	43,713
	transistors replaced		21
b.	Semiconductors in main machine (diodes, zeners, stabistors, etc.)		
		Total	81,946
	semiconductors replaced		5
c.	Number of printed circuit cards in I/O equipment		
		Total	1,655
	replaced		24
	number with dirty contacts		1
		Total	25

6.4.4 Parity Error Modification

On November 17, 1965, modifications were made to identify core parity errors or channel errors. This consisted of logic changes in CC14, Core 0, Core 1, interplay and channel 4 (1414A). Channel 5, 6, and 7 are to be modified at a later date.

When running in the interrupt mode, channel error (X2P2) and core parity failure (X6) will cause an interrupt while writing and it is now possible to distinguish between them. Users will not now be thrown off the machine due to channel errors.

6.5 Log Summaries

6.5.1 ILLIAC II Use

ILLIAC II

Summary of Use

October, 1965

Scheduled Engineering		63.00
Unscheduled Engineering		262.55
Engineering Development		106.25
Time-Sharing Development		96.20
Idle		3.00
Total Use		
Training and Education	12.41	
System Modification and Improvement	74.20	
Customer Use	125.19	
Use		212.20
Total		744.00

Summary of Machine Errors

Main Machine	15
Tape Channels	29
Power Supplies	19
Drum	1
Selectric Typewriter	12
Disk Channel	1
Total	77

ILLIAC II

Summary of Use

November, 1965

Scheduled Engineering		66.00
Unscheduled Engineering		135.07
Engineering Development		132.17
Time-Sharing Development		42.37
Idle		3.36
Power Off		5.20
Total Use		
Training and Education	4.25	
System Modification and Improvement	179.25	
Customer Use	151.13	
Use		335.03
Total		720.00

Summary of Machine Errors

Main Machine	20
Tape Channels	12
Power Supplies	11
Drum	2
Disk Channel	1
Total	46

ILLIAC II

Summary of Use

December, 1965

Scheduled Engineering		69.00
Unscheduled Engineering		58.10
Engineering Development		216.07
Time-Sharing Development		16.38
Idle		5.59
Total Use		
Training and Education	00.00	
System Modification and Improvement	76.45	
Customer Use	205.21	
Use		282.06
Total		648.00

Summary of Machine Errors

Main Machine	15
Tape Channels	5
Power Supplies	8
Total	28

Percentage Analysis of Time for Quarter

Use	Time	Percentage of Total
Engineering	752:04	35.6
Engineering Tests	356:57	16.9
Productive Use	654:34	31.0
Developmental	330:30	15.7
Idle and Power Off	17:55	.8
	2112:00	100.0

6.5.2 IBM 1401-III Use

1401-III

Summary of Use

October, 1965

Scheduled Engineering	241.47
Unscheduled Engineering	64.40
ILLIAC Prep.	273.21
Code Check	46.11
Other Use	55.31
Idle	62.30
Total	744.00

1401-III

Summary of Machine Errors

1401 Main Frame	1
1402 Card Reader-Punch	2
1403 Printer	2
Total	5

1401-III

Summary of Use

November, 1965

Scheduled Engineering	96.41
Unscheduled Engineering	42.49
ILLIAC Prep.	340.47
Code Check	11.04
Other Use	79.07
Idle	146.12
Power Off	3.20
Total	720.00

1401-III

Summary of Machine Errors

1401 Main Frame	3
1402 Card Reader-Punch	2
Total	5

1401-III

Summary of Use

December, 1965

Scheduled Engineering		31.41
Unscheduled Engineering		38.53
ILLIAC Prep.		320.43
Code Check		7.41
Other Use		119.53
Idle		129.09
	Total	648.00

1401-III

Summary of Errors

1401 Main Frame		1
1402 Card Read-Punch		1
1403 Printer		5
	Total	7

Percentage Analysis of Time for Quarter

Use	Time	Percentage of Total
Engineering	188:22	8.9
Engineering Tests	328:09	15.5
Productive Use	1254:18	59.4
Idle Time	337:20	16.0
Down Time	3:20	.2
	2112:00	100.0

7. IBM SERVICE, USE, AND PROGRAM DEVELOPMENT

(Supported in part by the National Science Foundation under Grant No. NSF-GP-700.)

7.1 New Routines

B3-U0I-EXP2-95-SR

Exponentiation. EXP2 raises a floating point number to an integer power.

Programmed by Fran Benard
August 23, 1965

D1-U0I-QUA2-93-SR

Evaluation of two-dimensional definite integrals by mechanical quadrature. Two-dimensional definite integrals may often be evaluated by the approximation

$$I = \int_c^d \left\{ \int_a^d F(X,Y)dX \right\} dY =$$

$$\sum_{k=1}^{N} B_k \left\{ \sum_{j=1}^{M} A_j F(X_j,Y_k) \right\} + R_{MN}$$

where (a,b) and (c,d) are the intervals of integration along the X and Y axes respectively, $F(X,Y)$ is the function to be integrated, the X_j and Y_k are the points in the region to be integrated at which the function will be evaluated, the A_j and B_k are the weights to be given to each evaluation, N is the number of different Y values, M is the number of different X values, and R_{MN} is the approximation error.

Programmed by John Ehrman
August 23, 1965

D1-UOI-QUA3-94-SR

Evaluation of three-dimensional definite integrals by mechanical quadrature. Three-diemnsional definite integrals may often by evaluated by the approximation

$$I = \int_e^f \left\{ \int_c^d \left\{ \int_a^b F(X,Y,Z)dX \right\} dY \right\} dZ =$$

$$\sum_{i=1}^{L} \left\{ C_i \sum_{k=1}^{N} \left\{ B_k \sum_{j=1}^{M} A_j F(x_j, Y_k, Z_i) \right\} \right\} + R_{LMN}$$

where (a,b), (c,d), and (e,f) are the intervals of integration along the X, Y, and Z axes respectively, F(X,Y,Z) is the function to be integrated, the X_j, Y_k, and Z_i are the points in the region to be integrated at which the function will be evaluated, the A_j, B_k, and C_i are the weights to be given to each evaluation, N is the number of different Y values, M is the number of different X values, L is the number of different Z values, and R_{LMN} is the approximation error.

Programmed by John Ehrman
September 30, 1965

CO-UOI-UTR2-85-SR

Given f(x) = 0, this subroutine finds a value for x within a given error in a specified interval (A, B). The interval (A, B) is stepped across starting from A, in specified increments Δx, until a change of sign occurs in the function f(x). Then this interval is halved a specified number of times until the root is found, or the iteration count is exceeded. The accuracy required and the number of iterations are specified by the user.

This method may be very time-consuming if high accuracy is required and if the evaluation of f(x) is complicated; however, this routine may be called to provide a good initial approximation to be used in a more sophisticated method.

July 12, 1965

CO-UOI-UTR3-86-SR

Given a set of simultaneous equations of the form

$$X_1 = f_1 (X_1, X_2, \ldots, X_n)$$

$$X_2 = f_2 (X_1, X_2, \ldots, X_n)$$

$$\ldots\ldots\ldots\ldots\ldots\ldots$$

$$X_n = f_n (X_1, X_2, \ldots, X_n)$$

this subroutine finds the values of X_i's within an error specified by the user.

The method used in the subroutine UTR1 is generalized to the treatment of two or more simultaneous nonlinear equations. The method is subject to the same restrictions as in routine UTR1.

July 12, 1965

7.2 Log Summaries

Table I - IBM 1401-I
Summary of Use
October, 1965

Scheduled Engineering	4:04
Unscheduled Engineering	14:53
Maintenance	8:08
7094 Preparation	478:02
Listing	12:43
Code Check	10:33
Tape Duplication	6:44
Tape Dump	7:53
Reproduction	14:54
SMP	33:52
Tape Testing	7:00
Illiac Preparation	2:40
Idle	23:09
Total	624:35

Table II - IBM 1401-I
Summary of Machine Errors
October, 1965

1401 Main Frame	5
1402 Card Reader Punch	8
1403 Printer	5
729 V Tapes Drives	3
Total	21

Table I - IBM 1401-II
Summary Of Use
October, 1965

Scheduled Engineering	1:35
Unscheduled Engineering	17:12
Maintenance	9:12
7094 Preparation	449:43
Listing	15:48
Code Check	16:33
Tape Dump	4:54
Reproduction	18:00
SMP	68:27
Tape Testing	7:55
Illiac Preparation	6:35
Idle	21:52
Total	637:46

Table II - IBM 1401-II
Summary of Machine Errors
October, 1965

1402 Card Reader Punch	11
1403 Printer	4
729 V Tapes Drives	2
Total	17

Table I - IBM 7094

Summary of Use

October, 1965

Scheduled Engineering				38:32
Unscheduled Engineering				7:38
Machine Maintenance				11:34
Idle				25:15
Miscellaneous (Operator training, tape rewind, tape mounting, both system and user, rerun of failing problems, tape skipping, destruction of clock reading.)				39:05
TOTAL USE				
Training and Education			14:41	
University Administrative Overhead Use			20:09	
System Modification and Improvement			38:29	
System Updating			3:02	
Customer Use				
In System		265:05		
Relinquish				
AGEC	20:13			
PHYCS	122:06			
		142:19		
Special Short Shots		1:01		
			408:25	
Total Use				484:46
Total Time On				606:50

Table II - IBM 7094

Summary of Machine Errors

October, 1965

729 VI Tape Drives	5
7094 Undetermined Errors	1
Total	6

7094 Table III October 1965

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
AAE	145	230	375	5	6	11	2 32.2	9 10.2	11 42.4
ADV	0	17	17	0	1	1	0.0	26.8	26.8
AGE	0	12	12	0	3	3	0.0	5.0	5.0
AGEC	0	82	82	0	12	12	0.0	22 43.7	22 43.7
AGRON	156	204	360	1	18	19	44.6	2 46.2	3 30.9
ANGEN	0	36	36	0	1	1	0.0	44.5	44.5
ANS	0	58	58	0	4	4	0.0	56.2	56.2
ANTH	32	0	32	2	0	2	1 49.4	0.0	1 49.4
ASTR	6	61	67	1	3	4	0.8	41.1	41.9
BECBS	0	38	38	0	1	1	0.0	54.0	54.0
BOT	0	11	11	0	1	1	0.0	18.8	18.8
CCARC	0	1	1	0	1	1	0.0	10.0	10.0
CCPSY	0	13	13	0	1	1	0.0	9.1	9.1
CE	139	1007	1146	3	42	45	35.7	46 59.7	47 35.5
CHE	66	1069	1135	2	37	39	22.6	33 54.4	34 17.1
CRC	0	8	8	0	1	1	0.0	7.4	7.4
DCS	60	116	176	2	5	7	14.3	1 51.1	2 5.5
DGS	0	1	1	0	1	1	0.0	1.3	1.3
DS	0	114	114	0	3	3	0.0	1 2.2	1 2.2
ECON	0	37	37	0	3	3	0.0	54.7	54.7
ED	0	9	9	0	3	3	0.0	9.5	9.5
EDPSY	0	3	3	0	1	1	0.0	19.9	19.9
EE	234	432	666	6	13	19	44.3	9 14.3	9 58.7
ENGLS	0	4	4	0	1	1	0.0	1.4	1.4
FOR	0	6	6	0	2	2	0.0	57.8	57.8
FT	0	7	7	0	1	1	0.0	1.2	1.2
GENE	14	0	14	1	0	1	9.6	0.0	9.6
GSBA	36	0	36	3	0	3	23.9	0.0	23.9
HORT	0	33	33	0	4	4	0.0	40.7	40.7
ICR	0	36	36	0	3	3	0.0	1 54.8	1 54.8

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
IE	75	48	123	2	1	3	24.0	32.0	56.1
IGPA	0	45	45	0	2	2	0.0	36.9	36.9
ILLDM	0	3	3	0	1	1	0.0	3.9	3.9
ILR	0	16	16	0	1	1	0.0	14.6	14.6
IREC	0	1	1	0	1	1	0.0	0.7	0.7
LIR	0	1	1	0	1	1	0.0	0.2	0.2
MATH	1332	6	1338	2	1	3	4 1.1	5.0	4 6.2
MATRL	0	110	110	0	3	3	0.0	2 21.6	2 21.6
ME	624	291	915	13	22	35	2 31.7	4 32.9	7 4.6
MMPE	0	65	65	0	4	4	0.0	22.4	22.4
MUSIC	0	4	4	0	1	1	0.0	0.9	0.9
NHS	0	43	43	0	1	1	0.0	39.8	39.8
NUCE	31	246	277	1	8	9	4.9	8 55.8	9 0.8
OIR	0	325	325	0	1	1	0.0	11 14.3	11 14.3
PHYCS	6	2645	2651	1	36	37	1.0	218 48.4	218 49.4
PSYCH	0	399	399	0	18	18	0.0	10 16.4	10 16.4
SCONS	0	39	39	0	1	1	0.0	37.7	37.7
SCS	0	11	11	0	2	2	0.0	7.1	7.1
SGS	0	15	15	0	1	1	0.0	2.9	2.9
SOC	0	24	24	0	2	2	0.0	1 33.4	1 33.4
SOCW	0	2	2	0	1	1	0.0	2.3	2.3
SRL	0	19	19	0	1	1	0.0	5.7	5.7
SWS	0	300	300	0	25	25	0.0	6 35.6	6 35.6
TAM	0	152	152	0	12	12	0.0	1 20.3	1 20.3
UNIHI	0	29	29	0	3	3	0.0	26.4	26.4
VMS	0	14	14	0	1	1	0.0	4.5	4.5
VPH	0	4	4	0	1	1	0.0	2.3	2.3
VTED	0	5	5	0	1	1	0.0	9.8	9.8

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
WPGU	0	5	5	0	1	1	0.0	9.0	9.0
XSSS[3]	0	143	143	0	1	1	0.0	1 1.4	1 1.4
ZOOL	0	7	7	0	1	1	0.0	1.3	1.3
Subtotal	2956	8662	11618	45	328	373	14 40.9	408 25.4	423 6.4
DCSSY[4]	0	1009	1009	0	19	19	0.0	38 28.8	38 28.8
XDCS[5]	0	82	82	0	1	1	0.0	3 2.0	3 2.0
SSUAD[6]	0	536	536	0	2	2	0.0	20 9.2	20 9.2
Total	2956	10289	13245	45	350	395	14 40.9	470 5.4	484 46.4

1 See list of departmental codes following
2 Training and Education
3 Special short shots
4 System Improvement and Modifications
5 System Updating
6 University Administrative Overhead Use

Table I - IBM 1401-I

Summary of Use

November, 1965

Scheduled Engineering	7:52
Unscheduled Engineering	18:35
Maintenance	10:29
7094 Preparation	411:25
Listing	21:18
Code Check	19:21
Tape Dump	10:38
Reproduction	3:40
SMP	59:07
Tape Label	:45
Illiac Preparation	3:25
Idle	13:50
Total	580:25

Table II - IBM 1401-I

Summary of Machine Errors

November, 1965

1401 Main Frame	4
1402 Card Reader Punch	14
1403 Printer	1
729 V Tape Drives	2
Total	21

Table I - IBM 1401-II

Summary of Use

November, 1965

Scheduled Engineering	1:40
Unscheduled Engineering	1:02
Maintenance	10:50
7094 Preparation	457:03
Listing	33:51
Code Check	14:47
Tape Dump	9:21
Reproduction	17:15
SMP	34:10
Tape Label	:35
Idle	11:12
Total	591:46

Table II - IBM 1401-II

Summary of Machine Errors

November, 1965

1401 Main Frame	4
1402 Card Reader Punch	1
1403 Printer	2
729 V Tape Drives	1
Total	8

Table I - IBM 7094

Summary of Use

November 1965

Scheduled Engineering				57:05
Unscheduled Engineering				9:19
Maintenance				14:13
Idle				15:29
Miscellaneous (Operator training, tape rewind, tape mounting, both system and user, rerun of failing problems, tape skipping, destruction of clock reading)				46:14
Total Use				
Training and Education			36:07	
System Updating			1:39	
System Improvement and Modification			29:55	
University Administrative Overhead Use			11:47	
Customer use				
In System		244:33		
Relinquish				
AGEC	8:32			
PHYCS	97:20			
		105:52		
Special Short Shots		:47		
			351:12	
		Total Use		430:40
		Total Time On		573:00

Table II - IBM 7094

Summary of Machine Errors

November, 1965

7607 Data Channel		1
729 VI Tape Drive		1
1301 Disk Storage Unit		5
	Total	7

7094 Table III November 1965

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
AAE	310	216	526	9	5	14	8 37.6	3 0.0	11 37.6
ADV	0	23	23	0	1	1	0.0	24.4	24.4
AGE	1	20	21	1	2	3	0.2	17.9	18.2
AGEC	4	107	111	1	20	21	0.3	11 20.6	11 21.0
AGRON	182	146	328	1	16	17	50.6	3 10.4	4 1.0
ANGEN	0	37	37	0	1	1	0.0	21.2	21.2
ANS	0	69	69	0	4	4	0.0	1 6.8	1 6.8
ANTH	12	0	12	1	0	1	22.5	0.0	22.5
ASTR	34	90	124	1	2	3	11.3	55.5	1 6.9
BECBS	0	39	39	0	3	3	0.0	31.1	31.1
BOT	0	27	27	0	1	1	0.0	1 16.4	1 16.4
CCPSY	0	11	11	0	1	1	0.0	17.0	17.0
CE	413	1102	1515	4	39	43	1 28.3	35 13.7	36 42.1
CHE	75	1167	1242	2	32	34	12.6	33 7.1	33 19.7
CRC	0	12	12	0	1	1	0.0	4.6	4.6
DCS	107	134	241	4	4	8	27.8	41.8	1 9.6
DS	0	84	84	0	7	7	0.0	1 0.6	1 0.6
ECON	0	83	83	0	5	5	0.0	55.7	55.7
ED	0	19	19	0	4	4	0.0	22.1	22.1
EDPSY	0	1	1	0	1	1	0.0	10.1	10.1
EDTES	0	1	1	0	1	1	0.0	0.2	0.2
EE	660	517	1177	7	16	23	2 42.8	10 36.4	13 19.3
ENGLS	0	14	14	0	1	1	0.0	24.5	24.5
FT	0	8	8	0	1	1	0.0	2.2	2.2
GENE	41	0	41	1	0	1	21.0	0.0	21.0
GEOL	0	6	6	0	1	1	0.0	1.3	1.3
GSBA	167	7	174	3	1	4	3 53.4	12.8	4 6.2
HORT	0	24	24	0	3	3	0.0	42.1	42.1
ICR	0	110	110	0	4	4	0.0	2 46.9	2 46.9

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
IE	116	16	132	3	1	4	24.3	14.2	38.6
IED	0	21	21	0	1	1	0.0	32.6	32.6
IGPA	0	16	16	0	2	2	0.0	28.1	28.1
ILR	0	28	28	0	1	1	0.0	11.0	11.0
INADM	50	0	50	1	0	1	12.1	0.0	12.1
LIBS	0	3	3	0	1	1	0.0	0.5	0.5
LIR	0	7	7	0	1	1	0.0	26.2	26.2
MATH	3855	3	3858	2	1	3	12 28.4	0.7	12 29.1
MATRL	0	264	264	0	7	7	0.0	5 21.8	5 21.8
ME	810	530	1340	15	28	43	3 46.1	6 59.3	10 45.5
MKTG	0	4	4	0	1	1	0.0	22.3	22.3
MMPE	0	40	40	0	2	2	0.0	19.2	19.2
NHS	0	45	45	0	3	3	0.0	44.6	44.6
NUCE	22	190	212	2	8	10	3.2	3 27.8	3 31.1
OIR	0	178	178	0	2	2	0.0	6 23.1	6 23.1
PEM	0	5	5	0	1	1	0.0	5.6	5.6
PHYCS	4	2737	2741	1	37	38	0.6	195 22.7	195 23.4
PSYCH	0	441	441	0	20	20	0.0	12 2.3	12 2.3
REC	0	1	1	0	1	1	0.0	1.1	1.1
SCONS	0	75	75	0	1	1	0.0	1 35.1	1 35.1
SCS	0	4	4	0	1	1	0.0	42.4	42.4
SGS	0	39	39	0	1	1	0.0	16.7	16.7
SOC	2	5	7	1	1	2	0.7	1.3	2.0
SOCW	0	8	8	0	2	2	0.0	38.2	38.2
SRL	0	25	25	0	1	1	0.0	11.4	11.4
SWS	0	204	204	0	13	13	0.0	2 15.7	2 15.7
TAM	13	270	283	1	13	14	2.0	1 30.2	1 32.3

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
UNIHI	0	36	36	0	3	3	0.0	45.9	45.9
VMS	0	8	8	0	2	2	0.0	6.5	6.5
VPH	0	7	7	0	1	1	0.0	1.6	1.6
WPGU	0	4	4	0	1	1	0.0	6.8	6.8
XSSS[3]	0	164	164	0	1	1	0.0	46.9	46.9
ZOOL	0	13	13	0	3	3	0.0	3.5	3.5
Subtotal	6878	9465	16343	61	339	400	36 6.8	351 12.7	387 19.6
DCSSY[4]	0	1096	1096	0	18	18	0.0	29 54.8	29 54.8
XDCS[5]	0	40	40	0	1	1	0.0	1 38.9	1 38.9
SSUAD[6]	0	346	346	0	2	2	0.0	11 47.1	11 47.1
Total	6878	10947	17825	61	360	421	36 6.8	394 33.5	430 40.4

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Improvement and Modifications
5 System Updating
6 University Administrative Overhead Use

Table I - IBM 1401-I

Summary of Use

December, 1965

Scheduled Engineering	7:00
Unscheduled Engineering	13:15
Maintenance	12:08
7094 Preparation	480:23
Listing	16:06
Code Check	11:46
Tape Dump	3:47
Reproduction	5:43
SMP	14:26
Tape Testing	:55
Idle	21:16
Total	591:30

Table II - IBM 1401-I

Summary of Machine Errors

December, 1965

1401 Main Frame	1
1402 Card Reader Punch	6
729 V Tape Drives	6
Air Conditioning	1
Total	14

Table I - IBM 1401-II

Summary of Use

December, 1965

Scheduled Engineering	5:35
Unscheduled Engineering	16:53
Maintenance	12:39
7094 Preparation	440:31
Listing	23:12
Code Check	5:54
Tape Dump	2:06
Reproduction	3:48
SMP	43:37
Tape Testing	2:06
Tape Label	2:12
Idle	22:43
Total	589:00

Table II - IBM 1401-II

Summary of Machine Errors

December, 1965

1401 Main Frame	3
1402 Card Reader Punch	10
1403 Printer	4
729 V Tape Drives	5
Air Conditioning	1
Total	23

Table I - IBM 7094

Summary of Machine Use

December, 1965

Scheduled Engineering				24:08
Unscheduled Engineering				3:55
Maintenance				14:14
Air Conditioning				2:15
Building Power Failure				2:48
Idle				24:56
Miscellaneous (Operator training, tape rewind, tape mounting, both system and user, rerun of failing problems, tape skipping, destruction of clock reading)				53:32
Total Use				
Training and Education			38:43	
University Administrative Overhead			12:55	
System Modification and Improvement			27:22	
System Updating			2:31	
Customer Usage				
In system		285:03		
Relinquish				
AGEC	23:34			
PHYCS	69:28			
		93:02		
Special Short Shots		:43		
			378:48	
			Total Use	460:19
			Total Time On	586:07

Table II - IBM 7094

Summary of Machine Errors

December, 1965

729 VI Tape Drive	4
7302 Core Storage	2
1301 Disk Storage	4
Total	10

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
AAE	236	127	363	7	6	13	2 11.0	1 54.1	4 5.2
ADV	0	22	22	0	1	1	0.0	34.6	34.6
AGE	0	2	2	0	2	2	0.0	7.3	7.3
AGEC	90	244	334	2	18	20	46.3	26 7.8	26 54.1
AGRON	333	179	512	1	18	19	2 42.5	3 12.4	5 55.0
ANGEN	0	35	35	0	1	1	0.0	8.6	8.6
ANS	0	42	42	0	4	4	0.0	1 17.7	1 17.7
ANTH	4	0	4	1	0	1	28.9	0.0	28.9
ASTR	28	96	124	1	2	3	15.9	1 0.0	1 15.9
BECBS	0	83	83	0	3	3	0.0	1 1.3	1 1.3
BOT	0	8	8	0	1	1	0.0	2.7	2.7
CCCHE	0	21	21	0	1	1	0.0	22.3	22.3
CCGEO	0	4	4	0	1	1	0.0	5.8	5.8
CCPSY	0	3	3	0	1	1	0.0	1.3	1.3
CE	687	1144	1831	4	49	53	3 54.2	36 39.4	40 33.7
CHE	128	1310	1438	1	41	42	37.4	42 15.8	42 53.3
CRC	0	3	3	0	1	1	0.0	2.8	2.8
DCS	165	84	249	4	6	10	50.8	44.2	1 35.0
DS	0	50	50	0	4	4	0.0	27.4	27.4
ECON	49	40	89	2	5	7	16.7	57.1	1 13.9
ED	0	33	33	0	5	5	0.0	44.2	44.2
EDTES	0	12	12	0	1	1	0.0	4.4	4.4
EE	372	666	1038	7	16	23	1 43.1	14 6.4	15 49.5
ENGLS	0	6	6	0	1	1	0.0	1.4	1.4
FIN	3	0	3	1	0	1	0.4	0.0	0.4
FOR	0	2	2	0	1	1	0.0	4.4	4.4
FT	0	18	18	0	1	1	0.0	12.1	12.1
GENE	52	0	52	1	0	1	12.8	0.0	12.8

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
GEOL	0	7	7	0	1	1	0.0	1.7	1.7
GSBA	184	6	190	3	1	4	3 15.8	58.0	4 13.8
HEC	0	2	2	0	1	1	0.0	3.2	3.2
HLTHS	0	1	1	0	1	1	0.0	4.7	4.7
HORT	0	25	25	0	3	3	0.0	30.8	30.8
ICR	0	153	153	0	3	3	0.0	3 0.9	3 0.9
IE	46	39	85	3	1	4	8.7	14.4	23.2
IGPA	0	58	58	0	2	2	0.0	39.4	39.4
ILR	0	41	41	0	1	1	0.0	50.0	50.0
INADM	80	0	80	2	0	2	42.3	0.0	42.3
LIR	0	4	4	0	1	1	0.0	1 12.8	1 12.8
MATH	3180	2	3182	2	1	3	11 55.6	0.9	11 56.5
MATRL	0	308	308	0	8	8	0.0	9 13.3	9 13.3
ME	1601	691	2292	16	32	48	7 34.4	9 42.3	17 16.8
MKTG	0	8	8	0	2	2	0.0	11.5	11.5
MMPE	0	70	70	0	4	4	0.0	41.8	41.8
NHS	0	56	56	0	2	2	0.0	38.6	38.6
NUCE	3	239	242	2	7	9	23.5	3 39.1	4 2.6
OIR	0	177	177	0	1	1	0.0	9 6.3	9 6.3
PHYCS	0	2985	2985	0	36	36	0.0	173 13.1	173 13.1
PSYCH	15	579	594	1	22	23	6.1	17 57.8	18 4.0
SCONS	0	86	86	0	1	1	0.0	1 20.8	1 20.8
SCS	0	4	4	0	1	1	0.0	5.1	5.1
SGS	0	16	16	0	1	1	0.0	4.7	4.7
SOC	3	10	13	1	3	4	8.7	4.4	13.1
SOCW	0	3	3	0	1	1	0.0	11.5	11.5
SRL	0	2	2	0	1	1	0.0	1.7	1.7
SWS	0	285	285	0	14	14	0.0	5 2.3	5 2.3
TAM	102	122	224	2	10	12	27.1	44.8	1 11.9

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
UNIHI	0	69	69	0	2	2	0.0	5 35.5	5 35.5
USGS	0	3	3	0	1	1	0.0	1.4	1.4
VMS	0	8	8	0	2	2	0.0	1.4	1.4
VTED	0	8	8	0	1	1	0.0	8.6	8.6
WPGU	0	6	6	0	1	1	0.0	5.3	5.3
XSSS[3]	0	118	118	0	1	1	0.0	43.1	43.1
ZOOL	0	14	14	0	2	2	0.0	16.6	16.6
Subtotal	7361	10439	17800	64	362	426	38 43.3	378 46.9	417 30.3
DCSSY[4]	0	888	888	0	19	19	0.0	27 22.5	27 22.5
XDCS[5]	0	51	51	0	1	1	0.0	2 30.7	2 30.7
SSUAD[6]	0	318	318	0	2	2	0.0	12 55.2	12 55.2
Total	7361	11696	19057	64	384	448	38 43.3	421 35.3	460 18.7

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Improvement and Modifications
5 System Updating
6 University Administrative Overhead Use

Quarterly Summary of Departmental Running Time
October, November, December 1965

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
AAE	691	573	1264	21	17	38	13 20.8	14 04.3	27 25.1
ADV	0	62	62	0	3	3	0.0	1 25.8	1 25.8
AGE	1	34	35	1	7	8	0.2	30.2	30.4
AGEC	94	433	527	3	50	53	46.6	60 12.1	60 58.7
AGRON	671	529	1200	3	52	55	4 17.7	9 09.0	13 26.7
ANGEN	0	108	108	0	3	3	0.0	1 14.3	1 14.3
ANS	0	169	169	0	12	12	0.0	3 20.7	3 20.7
ANTH	48	0	48	4	0	4	2 40.8	0.0	2 40.8
ASTR	68	247	315	3	7	10	28.0	2 36.6	3 04.6
BECBS	0	160	160	0	7	7	0.0	2 26.4	2 26.4
BOT	0	46	46	0	3	3	0.0	1 37.9	1 37.9
CCARC	0	1	1	0	1	1	0.0	10.0	10.0
CCCHE	0	21	21	0	1	1	0.0	22.3	22.3
CCGEO	0	4	4	0	1	1	0.0	05.8	05.8
CCPSY	0	27	27	0	3	3	0.0	27.4	27.4
CE	1239	3253	4492	11	130	141	5 58.2	118 52.8	124 51.0
CHE	269	3546	3815	5	110	115	1 12.6	109 17.3	110 29.9
CRC	0	23	23	0	3	3	0.0	14.8	14.8
DCS	332	334	666	10	15	25	1 32.9	3 17.1	4 50.0
DGS	0	1	1	0	1	1	0.0	01.3	01.3
DS	0	248	248	0	14	14	0.0	2 30.2	2 30.2
ECON	49	160	209	2	13	15	16.7	2 47.5	3 04.2
ED	0	61	61	0	12	12	0.0	1 15.8	1 15.8
EDPSY	0	4	4	0	2	2	0.0	30.0	30.0
EDTES	0	13	13	0	2	2	0.0	04.6	04.6
EE	1266	1615	2881	20	45	65	5 10.2	33 57.1	39 07.3
ENGLS	0	24	24	0	3	3	0.0	27.3	27.3
FIN	3	0	3	1	0	1	0.4	0.0	0.4
FOR	0	8	8	0	3	3	0.0	1 02.2	1 02.2

Quarterly Summary of Departmental Running Time
October, November, December 1965 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
FT	0	33	33	0	3	3	0.0	15.5	15.5
GENE	107	0	107	3	0	3	43.4	0.0	43.4
GEOL	0	13	13	0	2	2	0.0	03.0	03.0
GSBA	387	13	400	9	2	11	7 33.1	1 10.8	8 43.9
HEC	0	2	2	0	1	1	0.0	03.2	03.2
HLTHS	0	1	1	0	1	1	0.0	04.7	04.7
HORT	0	82	82	0	10	10	0.0	1 53.6	1 53.6
ICR	0	299	299	0	10	10	0.0	7 42.6	7 42.6
IE	237	103	340	8	3	11	57.0	1 00.6	1 57.6
IED	0	21	21	0	1	1	0.0	32.6	32.6
IGPA	0	119	119	0	6	6	0.0	1 44.4	1 44.4
ILLDM	0	3	3	0	1	1	0.0	03.9	03.9
ILR	0	85	85	0	3	3	0.0	1 15.6	1 15.6
INADM	130	0	130	3	0	3	54.4	0.0	54.4
IREC	0	1	1	0	1	1	0.0	00.7	00.7
LIBS	0	3	3	0	1	1	0.0	00.5	00.5
LIR	0	12	12	0	3	3	0.0	1 39.2	1 39.2
MATH	8367	11	8378	6	3	9	28 25.1	06.6	28 31.7
MATRL	0	682	682	0	18	18	0.0	16 56.7	16 56.7
ME	3035	1512	4547	44	82	126	13 52.2	21 14.5	35 06.7
MKTG	0	12	12	0	3	3	0.0	33.8	33.8
MMPE	0	175	175	0	10	10	0.0	1 23.4	1 23.4
MUSIC	0	4	4	0	1	1	0.0	0.9	0.9
NHS	0	144	144	0	6	6	0.0	2 03.0	2 03.0
NUCE	56	675	731	5	23	28	31.6	16 02.7	16 34.3
OIR	0	680	680	0	4	4	0.0	26 43.7	26 43.7
PEM	0	5	5	0	1	1	0.0	05.6	05.6
PHYCS	10	8367	8377	2	109	111	01.6	587 24.2	587 25.8
PSYCH	15	1419	1434	1	60	61	06.1	40 16.5	40 22.6
REC	0	1	1	0	1	1	0.0	01.1	01.1
SCONS	0	200	200	0	3	3	0.0	3 33.6	3 33.6

Quarterly Summary of Departmental Running Time
October, November, December 1965 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
SCS	0	19	19	0	4	4	0.0	54.6	54.6
SGS	0	70	70	0	3	3	0.0	23.4	24.3
SOC	5	39	44	2	6	8	09.4	1 39.1	1 48.5
SOCW	0	13	13	0	4	4	0.0	52.0	52.0
SRL	0	46	46	0	3	3	0.0	18.8	18.8
SWS	0	789	789	0	52	52	0.0	13 53.6	13 53.6
TAM	115	544	659	3	35	38	29.1	3 35.3	4 04.4
UNIHI	0	134	134	0	8	8	0.0	6 47.8	6 47.8
USGS	0	3	3	0	1	1	0.0	01.4	01.4
VMS	0	30	30	0	5	5	0.0	12.4	12.4
VPH	0	11	11	0	2	2	0.0	03.9	03.9
VTED	0	13	13	0	2	2	0.0	18.4	18.4
WGPU	0	15	15	0	3	3	0.0	21.1	21.1
XSSS[3]	0	425	425	0	3	3	0.0	2 31.4	2 31.4
ZOOL	0	34	34	0	6	6	0.0	21.4	21.4
Subtotal	17195	28566	45761	170	1029	1199	89 28.1	1138 13.5	1227 02.2
DCSSY[4]	0	2993	2993	0	56	56	0.0	95 46.1	95 46.1
XDCS[5]	0	173	173	0	3	3	0.0	7 11.6	7 11.6
SSUAD[6]	0	1200	1200	0	6	6	0.0	44 51.5	44 51.5
Total	17195	32932	50127	170	1094	1264	89 28.1	1286 02.7	1374 51.4

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Improvement and Modifications
5 System Updating
6 University Administrative Overhead Use

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8.1 Research Problem Specifications

During the last quarter of 1965, 153 problem specifications were submitted to the department for computation. The following brief descriptions of these problems have been prepared for inclusion in this report by those submitting them. T indicates a calculation associated with a thesis.

1667-5∅002 Agricultural Engineering. Seepage Analysis for Earth Fill Dams. The principal objective is to determine the efficiency of performing seepage analyses for earth fill dams by numerical methods, relative to analysis procedures based on graphical, electrical analog, or other selected techniques. The solution of an analysis problem will be considered to include the positions in two dimensions of the equipotential lines, stream lines, and seepage surface for a dam cross-section with steady state flow. Permeability of the cross-section can be homogeneous, non-homogeneous, or anisotropic.

Equipotentials and stream lines will be obtained in the numerical version through an iterative solution of a two-dimensional Laplace equation. The position of the free surface will be determined through a process of successive adjustments, subject to satisfaction of specified boundary conditions on the surface. (R. N. Fenzl)

1668-5∅003 T Department of Computer Science. Three Particle Distribution Function in He^4. A numerical investigation of the 3 particle distribution function in He^4 over a fairly wide range of temperatures will be performed in order to obtain the first density dependent term in the pair distribution function of He^4. The 3 particle distribution function is to be written in terms of Wiener integrals which will then be evaluated numerically by a Monte Carlo sampling procedure. The Wiener integrals are approximated by multiple integrals of fairly large dimension having Gaussian weights. These multiple integrals are then approximated by Monte Carlo sampling from appropriate Gaussian populations. (H. F. Jordan)

1669-5∅004 T Psychology. Rigidity and Attitude. This study is first a test of the hypothesis that cognitive rigidity will decrease the predictive validity of two recent attitude theories, and secondly a test of the usefulness of some of the major constructs in each of the theories in generating valid predictions. The SSUPAC library routines for conversion to standard scores, correlations, factor analysis, and analysis of variance will all be used. (Howard Marcum)

1670-5/005 Psychology. Repression-Sensitization II. The computer will be used to compare intercorrelations and reliabilities on seven variables for subgroups of subjects, in an investigation of stimulus generalization as a personality characteristic. This is a replication with a larger group of a previous repression-sensitization study. (Barbara Blaylock)

1671-5/006 I Industrial Engineering. Optimum Tool Angles for Maximum Tool Life. Preliminary calculations based on published data have indicated that for fixed metal cutting conditions (constant feed, speed, and depth of cut), tool life is a function of the geometry of the cutting tool.

The functional relationship between tool life and tool angles appears to be a second degree relationship, i.e. a distinct maximum tool life occurs for a given set of cutting conditions. The object of this thesis will be to establish that this relationship does exist and to establish the necessary statistical techniques to determine this maximum point both in the laboratory and on a production job.

The 7094 will be used initially to establish a maximum permissible amount of variance of experimental data which can be tolerated in the experimental phase. This will be done by simulating experiments which are run on known second degree tool life relationships. The statistical tools which are to be used in this step can be classified under the name of response surface methodology (RSM). RSM is basically an extension of multiple regression techniques.

In the experimental phase of this work the 7094 will be used to determine the location of the next experiment in the vector space defined by the independent variables. This new location is a function of all previous experimental points and is determined by the statistical tools of RSM. (Lloyd Lehn)

1672-5/009 Illinois State Department of Mental Health. Survey of Illinois Mental Health Programs. This is a study of the attitudes of community leaders toward mental illness and mental health programs. The data were solicited by personally interviewing 209 community leaders in Sangamon County, Illinois.

The data will be used to help structure education programs relative to the new community mental health program in Illinois. (Smith)

1673-5∅010 T Physics. π^{o} Photoproduction From He^{4}. The brehmsstrahlung from the University of Illinois 300 Mev betatron will be used to photoproduce neutral pions in a helium-4 target. Gamma rays produced from the pion decay will be registered by detectors and the resulting pulse heights used to determine the cross section and form factor of the helium-4 nucleus. The computer will be used in analyzing the data by calculating statistical curves and correlating the data. (John Staples)

1674-5∅011 T Material Research Laboratory. Internal Friction Studies, MATRL. This is a continuation of internal friction studies originally begun on problem specification number 56010. A theoretical prediction of the strain amplitude dependance of internal friction in metals due to dislocation motion is being developed. The computer is used to mock-up a sample dislocation array. The way this array changes under applied stress is calculated and the changes in internal friction resulting are calculated. The computer may also be used to fit experimental data to the theoretical predictions in order to calculate certain parameters such as the pinning concentration and strength. (Trott)

1675-5∅019 Material Research Laboratory. Crystallographic Theory of Composite Martensite. The crystallographic theory of first order phase transformations utilizes techniques of matrix algebra and/or equivalent operations on a stereiographic projection. The latter are much less precise but are more convenient and of greater heuristic value. The operations involve distortion, transformation, and shear matrices as well as unitary orthogonal matrices used as rotations and as similarity transformations. These matrices are, for the most part, non-symmetric. The computer will use an iterative procedure to manipulate these matrices. Both existing routines in the library and new routines which are to be written will be used in this process. (Lieberman)

1676-5∅020 Material Research Laboratory. Analysis of Thermal Conductivity. This problem specification replaces 4D005. (M. V. Klein)

1677-5∅021 T Civil Engineering. Numerical Solution of Shells. The equilibrium equations of shells in terms of the 3 displacements are generated. These equations, which are a set of linear algebraic simultaneous equations, are solved and the forces and moments are computed. (Bijan Mohraz)

1678-5∅022 T Animal Science. Dietary Cations and Anions. This is a study of the effects of dietary cations and anions on rat growth. Other criteria to be investigated are mineral and nitrogen excretions and balances. The data will be analyzed by the Least Squares Method. (A. L. Melliere)

1679-5∅023 T Civil Engineering. Interaction of Elastic-Perfectly Plastic Plane Waves with a Tunnel-like Cavity. The problem of studying transmission of stress waves in soils arises from the need to have an estimate of the dynamic pressures transmitted to an underground structure when a blast occurs nearby.

The overpressure produced at the boundary of a semi-infinite soil medium which contains a tunnel-like cavity, travels downward as a plane wave. The soil is assumed to be a Prandtl-Reuss material, i.e., a material with an elastic-perfectly plastic behavior. It is intended to determine the stress and the strain around the cavity, due to the incident wave produced by a surface blast.

The technique of digital simulation of the given continuum will be employed to solve the problem. It involves a lumped-parameter discrete model whose equations, numbered over a thousand, will be solved by Newmark's β-method. (G. C. Y. Chang)

1680-5∅024 Civil Engineering. Dynamics of Beams. This is a study of the dynamic response of beams. The mathematical method to be used is the well known method of characteristics for the numerical solution of partial differential equations. (W. J. Winkel)

1681-5∅025 Survey Research Laboratory. Non-Numeric Punch Conversion. A considerable amount of data (cards) held by the Data Repository (Survey Research Laboratory) has plus, minus, and amp punches. In many cases, only one-column codes are involved; however, there are some two and three column codes with all combinations of numeric and these three non-numeric punches. A program will be written to enable researchers to analyze the mass of data on the IBM 7094 with SSUPAC. This project is consonant with DR policy of making certain bodies of data available to clients in a useful, efficient, and economical form. (Philip S. Schuman)

1682-5∅026 Psychology. Validation of the Behavior Differential. The problem concerns the validation of a psychological test, referred to as the Behavioral Differential. Ordinary statistical tests of significance, correlational analysis and factor analyses will be used. (M. Wilkins)

1683-5∅027 Institute for Research on Exceptional Children. Deaf Adults Study. This study is presently concerned with the adjustment of deaf college students to experiences in regular colleges and universities. The study is based upon a mailed questionnaire survey of deaf persons with experience in a regular (hearing) college and university. It has two basic aims: (1) to obtain information regarding practical steps which both (a) hearing colleges and universities and (b) deaf persons themselves can take to improve their chances for acquiring a satisfactory education at regular hearing colleges; (2) to gather information which will permit prediction of the degree of success attained by a deaf person in his pursuit of an education at a hearing institution. (Stephen P. Quigley)

1684-5∅028 Nuclear Engineering. Nuclear Code Library. A few computer codes concerning nuclear reactor design will be tested. These codes will be used as teaching aids in the nuclear engineering program. Sample problems on neutron diffusion, slowing-down, thermalization, reactor kinetics, reactor heat transfer, gamma ray shielding, activation analysis, neutron pulse propagation and so on are to be run. These codes are all in the FORTRAN language. (K. Y. Cheung)

1685-5∅033 T Electrical Engineering. Impedance of Loop in Plasma. The theoretical expressions for the input impedance of a small loop of electric current immersed in a magneto-ionic medium have been derived. The expression involves the use of complete elliptic integrals of the first and second kind, whose arguments are complex functions of the magneto-plasma parameters. The impedance expression is a function of 7 parameters in all and will give rise to a possible total of 1800 impedance calculations which will be accomplished by nested loop programming. The complete elliptic integrals will be calculated by means of hypergeometric functions and written to handle complex numbers in general. In addition, a one dimensional integral will be calculated using a simple quadrature technique from the library routines. (G. L. Duff)

1686-5∅034 Department of Computer Science. Simulation of Optical Transform Systems. Optical systems are available to produce the spatial Fourier transform of planar figures. The computer will be used to simulate some of these systems to determine transform characteristics of various character sets and patterns and to facilitate an analysis of optical fitter techniques for recognizing and reconstructing figures contaminated by noise. (D. S. Sand)

1687-5∅035 Chicago Circle Psychology. Non-Intellective Factors Affecting Scholastic Achievement. The purpose of the research is to determine the relationship of selected personality and motivational factors affecting academic achievement in college. Scoring programs will be written to compute such variables as (a) the discrepancy between each subject's attitudes and both those predominant in the college environment and those of his parents; (b) the relevance of academically-oriented behavior to attainment of each of a set of goals deemed important; etc. These scores will then be analyzed statistically as a function of sex, socioeconomic class, academic aptitude, and grade point average. Analyses of variance procedures will largely be used. Possible effects of other selected motivational and personality variables will also be analyzed. Data on about 2000 students will be processed. (Robert Wyer)

1688-5∅036 Mechanical Engineering. Spur Gear Design. This problem will involve combining the strength, wear, and scoring criteria associated with spur gears into a computer program that will enable the user to design spur gears. The completed program will be used to supplement lecture presentations in design courses. (D. H. Offner)

1689-5∅037 Social Work. Recidivism. Test of certain hypotheses concerning the relation between recidivism among juvenile offenders and selected factors, e.g. age at first offense. About one thousand juvenile offenders in one county have been identified for a five year time period, and data gathered from various official records. Contingency analysis and tests of significance (such as chi-square) will be used. (Griffiths)

1690-5∅038 Mechanical Engineering. Computerized Load Calculation. This research problem deals chiefly with the computerization of heating and cooling load calculations for a medium size building. The purpose is to develop a computer program which will provide a more accurate, more thorough, faster, and lower cost means of load calculation than the standard method of hand calculation. (Jack Esmond)

1691-5∅039 Electrical Engineering. Lateral Effects in p-n Junctions. The solution of a non-linear differential equation by the Runge-Kutta technique is required. The method of binary cut is used to adjust the starting parameters of the solution so that boundary conditions at the two separate ends of the region of interest correspond to a physically meaningful value. From this solution the voltage variation in a thin water containing a p-n junction can be determined as a function of the coordinates lying in the plane of the thin water. (Kenneth K. Knaell)

1692-5∅042 T Theoretical and Applied Mechanics. Relative Retardation of Light Due to Rotation of Secondary Principal Stresses. Recent advancements in scattered light equipment used for experimental stress analysis has caused renewed interest in the effects of rotation of the "light vector" as it passes through a photoelastic model. Theoretically, the relative

retardation is governed by Newmann's equation which cannot be solved explicitly for the general case. However, for special cases, Newmann's equation can be solved approximately by iteration at a finite number of points along the light path. It is desirable to compare the theoretical approximations with experimental results for several cases. (W. Jorgenson)

1693-5∅043 Physics. W-Production. This problem concerns the calculation of W boson production cross sections by proton-proton collision. The computer will be used for: (1) Numerical calculation of deuteron form factors and kinematical quantities; (2) Numerical calculation of helicity amplitudes; and (3) Calculation of cross section as a function of the mass of the W boson and the total energy. (Uchiyama)

1694-5∅044 Civil Engineering. Density Measurement Using Gamma Radiation. For apparatus which measures the density of a material by gamma ray transmission, a differential equation can be written which gives the count rate due to a differential volumn of specimen. The integration of this equation cannot be performed analytically, but can be done numerically. The equations for various systems of this type at present being used, are integrated so as to give the distribution of radiation within the specimen, and to investigate the effect of causes of errors such as variations in specimen size and chemical composition. (Preiss)

1695-5∅045 Civil Engineering. Design of Reinforced Concrete Columns Subject to Bending. The purpose of this problem is to develop an approach for optimization of cost in design of eccentrically loaded columns. It is intended to use a program which has recently been developed to obtain a number of interaction diagrams for eccentrically loaded reinforced concrete columns. In this problem the load is plotted against the moment, both of which are in dimensionless form. These diagrams will be drawn for the ultimate load for the practical range of the variables. (K. Clausen)

1696-5∅049 T Theoretical and Applied Mechanics. Velocity Profile Data Reduction. A study of three-dimensional flow in turbo machinery is being made using Euler's equation of motion for the inviscid flow together with boundary layer theory for viscous effects. The computer will be used for reducing experimental data (velocity and pressure measurements), integrating, and solving systems of simultaneous linear differential equations. (R. C. Hansen)

1697-5∅050 Chemistry and Chemical Engineering. LCAO MO Calculations. This research problem will investigate the nature of the eigenvector output data as a function of various Coulomb integral refinements. These eigenvectors will be used later to evaluate expectation values of several one-electron operators. This work applies to some transition metal carbonyl hydrides. An existing program will be used to make molecular orbital calculations of the linear combination of atomic orbitals type. The program calculates overlap matrix elements, molecular orbital energies, and eigenvectors, and will perform atomic charge iterations (based on Mulliken's population analysis). (Schreiner)

1698-5∅051 T Aeronautical and Astronautical Engineering. Shock Tube Study of a Highly Endothermic Chemical Reaction. The computer is to be used to investigate the effect of a highly endothermic reaction in a shock tube on a reflected shock wave and the gas properties behind the reflected shock wave. The specific reaction to be studied is the dissociation of argon.

The gas properties in the shock tube will be determined through the construction of a Method of Characteristics wave net. The wave net will be constructed through the use of an iterative scheme that necessitates the use of a computer for reasonable accuracy. The merging of waves in the net signifies the formation of shock waves, and the merging of other waves with the shock waves determines the strength of the shock waves at various points in the net. The computer is necessary to obtain an accurate description of these shock waves through the use of another iterative scheme. (Lee Nafziger)

1699-5∅052 Material Research Laboratory. The F-Centre in Fluorite Structures. The point ion method, which retains only the spherically symmetric part of the crystal potential, is used to compute the energy levels on an electron localized about the F vacancy in the various fluorite structures. The first twenty-two shells of the crystal potential will be included in these calculations. Three types of trial wave functions will be employed in order to obtain expressions for the energy of the trapped electron as a function of the trial wave function parameter (effective range) and as a function of the lattice distortion. These trial wave functions are: (i) hydrogenic; (ii) composite functions appropriate to a potential which is constant and negative for distances less than the nearest neighbor distance and is coulombic for distances greater than the nearest neighbor distance; (iii) composite functions appropriate to a potential which is constant and negative for distances less than the nearest neighbor distance and constant and positive for distances greater than the nearest neighbor distance. The effects of nearest neighbor polarization and the relaxation of the lattice will also be included.

Hence, from theory an expression for the energy, which will contain two parameters, is obtained. The computer is used to find the minimum of a function of two variables. (H. S. Bennett)

1700-5∅057 Mechanical Engineering. Polyspecie Interdiffusion. The problem is one of determining the locus of the principal chemical reaction (emission of the CO or swan band lines) in a constant velocity, interdiffusing flow system. The procedure will be to superimpose the equilibrium conditions upon a system of polyspecies interdiffusion.

The equilibrium conditions will be defined by the Duff encoding of the Brinkley technique, and the interdiffusion will be handled by finite difference solutions of the equation $\frac{\partial C_n}{\partial x} = \frac{1}{v} \frac{\partial}{\partial r} \left(D_n \, r \, \frac{\partial C_n}{\partial r} \right)$ for each on n chemical species. Here, C_n = concentration, x = axial distance, r = radius, v = velocity, D_n = diffusion coefficient (self). (L. D. Savage)

1701-5∅058 Electrical Engineering. Satellite Ephemeris. The main objective of the "Satellite Ephemeris" problem is to obtain the electron content of the ionosphere through radio signal studies from radio satellite.

There are two major phenomena involved in satellite signal studies, one is the scintillation of satellite signal, the other is the Faraday rotation of the radio signal passing through the ionosphere. The input data of the program are the sub-satellite points in latitude and longitude at different times. Two types of computer output are obtainable, the first being suitable for scintillation studies and the second for Faraday rotation computations. Since most work in the ionosphere at one time or another involves the use of the earth's magnetic field, the Legendre and associated Legendre polynomials are solved by a given set of Gaussian coefficients through a large number of computer computations and transformations in times and in positions. The computer output thus obtained will be the calculated electron content. (C. Hsieh)

1702-5∅059 Mechanical Engineering. Impedance Calculations. The flow and pressure in a complex high pressure piping system with positive displacement compressor inputs is to be determined by means of a frequency domain analysis. The analysis is based on the analogy between the piping system and an electrical transmission line. This transforms the problem into the solution of the well known transmission line equations for a line composed of sections with different parameters arranged in an arbitrary manner. (B. F. Von Turkovich)

1703-5∅060 Mechanical Engineering. Pressure Waves. The problem is one of translating thermodynamic wave phenomena from Eulerian coordinates into La Grangian coordinates with a prescribed forcing effect, so that the influence of wave phenomena upon the thermodynamics of a reactable mixture may be studied. The basic coding for this problem has been accomplished in the Naval Ordinance Laboratories program for the analysis of light gas gun cycles. (L. D. Savage)

1704-50061 T Theoretical and Applied Mechanics. Stored Energy of Cold Worked Metals. Stored energy of cold work measurements are being made on cyclically twisted tubes of OFHC copper using a rise in temperature technique and the differential annealing technique of Clarebrough, et al. Specific items of investigation include: (a) Detailed measurements of the dissipation, storage and release of energy during the traversal of individual hysteresis loops. (b) Measurements of the cyclic accumulation of stored energy in initially annealed samples and the cyclic release of stored energy from initially cold worked samples. (c) Investigation of the possibility of a complete mechanical to thermal energy exchange once the mechanical hysteresis loop reaches a cyclically stable steady state condition. (d) Analysis of the mechanisms of energy dissipation and storage in the cyclic state.

The computer is to be used in this project to speed the reduction of raw experimental data into meaningful form. The research program calls for the testing of about 20 specimens, with 50 data points per cycle and an average of approximately 50 cycles per specimen (a total of 50,000 data points). (G. R. Halford)

1705-50062 Agronomy. Cultural Management and Climatic Factors on Maturation of Field Crops. Analysis of variance will be used to test different treatments (planting patterns, fertility levels, varieties) relative to significant differences for any or all of the following characters for both corn and soybeans: yield per acre; protein content; amino acids; yield components, expressed as wt. of 100 kernels, number of kernels per row, number of rows per ear; leaf areas. These experiments may be run at different locations. (Carmer)

1706-50063 Theoretical and Applied Mechanics. Approximate Methods for Boundary-Value Problems. Statical and steady-state diffraction problems in classical elasticity lead to integral equations of the Fredholm type for which the kernels are known. One seeks here a double or single vector layer to satisfy boundary conditions. Such problems can be approached through application of finite-difference techniques to the integral equations. The mesh involved is only a 2-dimensional network on the surface of the body. Furthermore, the surface distributions represent exact solutions of the differential equations. Accordingly, the analysis concentrates only on enforcement of boundary conditions.

Another method to be studied is an orthogonality procedure that is related closely to the mathematical theory of moments. The Galerkin method is a special case of it.

A third procedure under investigation is a combination of finite-difference formulas with stationary principles, such as minimum potential energy, minimum complementary energy, and least action. It may have an advantage over finite-difference approximations of the differential equations, since the orders of the derivatives in the differential equations are ordinarily twice as great as in the functional that is to be minimized. This method may be used in vibration problems; it is an alternative to the lumped-mass method.

Some problems of beams, plates, and shells will be studied, and the feasibility and accuracy of the last two methods in these areas will be compared with other methods. The work is partly comparative, but the main purpose is to develop new and useful methods for treating linear and nonlinear problems of elastic structures with the aid of the digital computer.
(H. Langhaar)

1707-50064 University High School. Culturally Deprived Children of High Ability. This study is concerned with the identification and evaluation of the psycho, social, and educational development of culturally deprived children of higher intellectual ability. Previous studies such as those of Spitz, Hunt, and others have found that children with limited experiential backgrounds fail to develop to the extent attained by more fortunate children. In view of present problems, it is imperative that each child be encouraged and helped to develop to his fullest potential for the sake of his country as well as himself. One way in which this problem may be alleviated may be to identify and develop a better understanding of those disadvantaged children who may have potential for leadership and creativity since they may be able to help others like themselves overcome deficits in the future.

This study is only Part I of a two part study designed to, first, identify and describe the characteristics of culturally deprived children of higher intellectual ability and, then, to provide a revised curriculum designed to overcome the delineated areas of deficiency.

Two hundred and sixty children have been identified who attained scores that placed them in the top twenty per cent of the culturally deprived population from which they were drawn. Each of these children was then administered a battery of tests including measures of academic achievement, psycholinguistic development, creative thinking, intellectual functioning and perceptions of the attitudes of peers, parents, and teachers which results in approximately 100 scores for each child.

Analysis of the data will be by appropriate statistical methods which may include correlation, factor analysis, frequency distributions and/or analysis of variance depending upon the extent to which the data satisfy the assumptions underlying each method. (W. M. Rogge)

1708-5Ø070 Veterinary Medical Science. Admission and Selection of College of Veterinary Medicine Students. A list of variables related to success in the College of Veterinary Medicine will be studied. It is hoped that some effective predictors of success will be found. Some of the variables included are high school grade point, high school rank, sex, and the students pre-vet grade point. Success in the College of Veterinary Medicine will be measured by the student's grade point average. These and other variables will be tested on a trial and error basis until some correlation is found.

Standard statistical routines from SSUPAC such as t-test, ANOVA, and Analysis of Regression will be used. If it proves necessary in the future some other routines may be written. (Weber)

1709-5Ø071 Mechanical Engineering. Effect of Various Terms in Reynolds Equation on Gear Load Capacity. Reynold's equation can be integrated twice to obtain the pressure distribution in an oil film between two gear teeth. This pressure distribution can then be integrated over the length of film to obtain the load that the film will support. In integrating Reynold's equation two constants of integration have to be established. Boundary conditions which determine these constants are that the pressure is zero at the beginning of the film and both the pressure and pressure gradient are zero at some point in the divergent portion of the film. These integrations are performed numerically for three different gear ratios. For each gear ratio the effect

of cylindrical approximations of the involute tooth surfaces are studied as well as the effect of the surface curvature terms in the Reynold's equation. All integrations are performed using Simpson's Rule. The point in the divergent film where the pressure and pressure gradient are zero is established using an interval-halfing method. (R. W. Adkins)

1710-50072 Institute of Communications Research. Person-Perception. When raters are assigned the task of rating another person on a standard personality test, the question is raised as to whether such ratings yield more information about the person doing the rating as compared with the person being rated. The veridicality of such ratings is questioned and an attempt is made to determine the sources of error in such rating tasks. It is further assumed that much of the rating error can be directly related to the a priori conceptual scheme of the rater. Toward this aim groups of women living together were assigned the task of rating one another on a standard adjective check list, along with the tasks of rating themselves, rating their ideal selves, rating themselves as others see them, etc. Further, a test was administered which presumably yields information related to the constructs utilized by the subjects in viewing their world. The data analysis will involve obtaining various descriptive statistics of the data (means, standard deviations, etc.) along with the underlying factors which might account for such ratings. Thus, eigenvalue, eigenvector subroutines will be used along with various kinds of rotational procedures such as oblimax and varimax. Since similar data have been collected at Stanford University, this additional data will be put on tapes and utilized in the present analysis. (Wiggins)

1711-50073 Mechanical Engineering. Minor Heat Transfer Problems. This specification number is requested for the solution of problems arising during the course of heat transfer investigations. These problems are generally field problems of the form $\frac{\partial T}{\partial t} = \frac{\partial}{\partial x}\left(a \frac{\partial T}{\partial x}\right) + \frac{\partial}{\partial y}\left(a \frac{\partial T}{\partial y}\right)$ for various geometric forms. T = temperature, t = time, a = a coefficient. The solution techniques employed are finite differences, relaxation, and random walk. (L. D. Savage)

1712-5∅075 Civil Engineering. Numerical Analysis of Shells by Integral Equations. Boundary value problems in elasticity are to be formulated in terms of integral equations by integrating particular singular solutions on the boundaries. The integral equations are to be solved numerically by approximating them by systems of linear algebraic equations which are then to be solved by Gauss elimination or other standard techniques. A study is to be made of the methods of integration, errors of approximation, and effects of parameter variation. (Delroy Forbes)

1713-5∅076 Department of Computer Science. Extrapolated Gauss-Seidel. Iterative techniques for solving systems of equations arising from elliptic partial differential equations have been studied extensively in the past using uniform extrapolation. That is, the same factor is used for every point, or for every block. In this study, numerical experiments will be carried out to determine the advantage to be gained by using different factors for each point or block. (Donald B. Gillies)

1714-5∅077 Material Research Laboratory. F-Center Energy Levels. The semicontinuum model is to be used to compute energy levels and wave functions for the F center in alkali halides. Particular attention will be given to the effect of parameter variation on the results. An existing FORTRAN program, which solves the Schrödinger equation for spherically symmetric potentials, will be used in this study. It is intended to compare the "exact" results obtained with the above program with approximate results obtained by a variational technique. (Fowler W. Beall)

1715-5∅078 T Mechanical Engineering. Two-Dimensional Supersonic Jet Impingement. This problem deals with the determination of the flow properties in the region of two confined, two-dimensional supersonic jets with constant pressure boundaries. The well-known method of characteristics, in the form of finite difference equations with iterative solutions, will be employed in finding the required solutions from the given boundary conditions. (R. E. Eilers)

1716-5∅079 T Mechanical Engineering. Air Curtain Calculations. The object of this project is to analytically and experimentally study the performance of air curtains. An air curtain is a two-dimensional jet of air which serves as a door, separating areas at different temperatures and pressures.

The computer may be of help in two ways: 1. By solving differential equations numerically, and thus helping to arrive at an analytical solution. 2. By calculating, summarizing, tabulating, and plotting experimental data. (Floyd Hayes)

1717-5∅080 T Material Research Laboratory. Screening of Electric Fields in Metals. This thesis studies the effects caused by impurities in a metal which create electric field gradients. The field gradients interact with the quadrupole moments of nuclei in the host lattice. By applying an electromagnetic field at the appropriate frequency, the quadrupole transitions absorb heat from the field. This can be detected by later measuring the nuclear spin temperature. By varying the magnitude, H, of the applied electromagnetic field one can study the rate of spin heating. The computer will be used to compare the experimental results with theoretically predicted values. (Nils Fernelius)

1718-5∅081 Zoology. Mouse Calculations. An analysis of the causes of variance in dental traits of the house mouse (Mus musculus) is being used to determine the relative effects of genetics and environment in the system. Standard routines of variance analysis and correlation will be used. An attempt will be made to construct a model of the system using stochastic processes. (Paul John Tenczar)

1719-5∅082 T Civil Engineering. Stress Concentration Factors for Projecting Notches. The problem involves the study of the effects of the different geometrical parameters characterizing the profile of projecting notches on the associated stress concentration factors. The analysis for the stresses in a rectangular bar of symmetrically disposed projecting notches under axial loading employs a finite difference solution of the pertinent elasticity equations. This solution requires the solution of a large set of simultaneous equations by iteration. (Arnaldo T. Derecho)

1720-50083 Mechanical Engineering. Two Dimensional Flap Nozzle. The two dimensional compressible potential flow passed through flap nozzles can be studied by hodograph transformation and tangent-gas approximations. The equivalent incompressible potential flow can be solved by Kiechhoff's free streamline theory, and the constant-velocity and constant streamline angle lines in the compressible flow can be found by integrating numerically the transformation relationship. The isentropic flow field (in particular, the sonic line) can be established with the assumption that the streamline angles are the same as that of the tangent gas near the sonic region and the subsequent flow field can be calculated by the method of characteristics.

Standard library subroutines will be employed in these calculations, and special complex integration subroutines will be developed. (W. L. Chow)

1721-50084 Mechanical Engineering. Hypersonic Slip Flow Past a Flat Plate. It is hoped that the hypersonic slip flow past a flat plate can be studied by the integral method. The velocity and temperature profiles will be established by the slip boundary conditions. The integral conservation principles will be employed to yield differential equations relating the strength and the derivatives of the shock waves. Numerical integrations will be carried out with parametric initial conditions. The standard library subroutines will be used. (W. L. Chow)

1722-50089 Mechanical Engineering. Thermal Modeling of Spacecraft. The problem concerns the prediction of transient temperature distribution in spacecrafts using model testing. While the similarity criteria have already been formulated, realistic and practical means to satisfy these criteria have yet to be devised. In this connection, the behavior of transient temperature fields in layerlike or sandwich materials with radiation surface conditions needs to be examined. The computer will be used in the analysis of such problems. It is anticipated that, at least in the preliminary investigation, relatively simple programs will be used involving standard library routines. Special mathematical methods, if used, will be reported in due course. Conceivably, the computer will also be used in the analysis of experimental data which are expected to become available in May or June of 1966. (B. T. Chao)

1723-5Ø091 Mining, Metallurgy, and Petroleum Engineering. Band Structure of Metals. The problem is to calculate the electronic band structure of bismuth by the pseudo-potential method. As spin-orbit coupling effects are to be included, the secular equation to be diagonalized is complex. Thus a fast routine to diagonalize large (up to 90 x 90) complex hermitian matrices will be written. (Stuart Golin)

1724-5Ø092 Material Research Laboratory. Impurities in Metals. Various experimental data are available on the behavior of some metals - notably lithium, sodium, copper, gold, silver - when impurities are put into the pure metal. Using known potentials for the impurities and known properties of the metals, it is desired to compare the theoretical values for quantities such as electrical resistance with the experimental data. Schrödinger's equation for various angular momentum states, energies and potentials will be solved. (M. A. Ball)

1725-5N001 Mechanical Engineering. Drill Calculations. The normal rake has been found to be the most significant angle in metal cutting. The normal rake will vary along the rake face on a standard twist drill. A method has been devised to hold the normal rake a constant value. There is reason to believe that with a constant normal rake angle one can improve drill life.

This project is centered around finding an optimum normal rake for drilling heat treated malleable iron under a fixed feed and speed for the drill. For this purpose, three parameters will be varied, as follows: (1) the normal rake; (2) the radius from the center of the drill to various points on the cutting surface; (3) the half point angle. (Roy Williams)

1726-5N002 T Electrical Engineering. A Study of a Plasma-Waveguide Discontinuity. The problem being considered is the solution for waves propagating in a parallel-plate waveguide with a plane discontinuity and filled with a lossless plasma and a transverse static magnetic field. The fields are assumed to be infinite series of orthogonal functions. The waves are matched at the discontinuity and boundary conditions are applied. This leads to an

infinite set of algebraic equations in an infinite number of unknowns. An approximate solution can be obtained by limiting the set to n equations and n unknowns. n is taken large enough so that the error in unknowns is as small as desirable. Theoretically it is possible to obtain an exact answer by letting n approach infinity. Only an approximate solution will be obtained here, however. (L. M. Peterson)

1727-5N003 T Graduate School of Business Administration. Combining Time Series Data With Cross-Section Data. Regression analysis is to be applied to observations of consumer unit behavior in an attempt to develop behavioral models. These behavioral models are to be combined with time series data for the purpose of constructing demand functions capable of explaining the temporal variation of expenditure for food, medical care, and house furnishings. (D. J. Laughhunn)

1728-5N005 T Zoology. Response of a Cichlid Fish to a Mirror. The temporal distribution of attacks by a fish to its mirror image is recorded. Then, given a definition of an attack "bout," the computer will calculate various bout measures such as the number of attacks, length in time, changes in the attack frequency as the bout progresses, and the length of the interval to the next bout. Correlations and regression lines between various bout measures will be computed. The machine will be used to determine the conditional distribution of attack frequencies on the number of attacks in a preceding unit of time. When the data for a sizable number of fish (of the same species) have been thusly organized, various significance tests (most likely non-parametric) will be performed to determine how rigidly the measures obtained conform from one fish to another. The ultimate goal is not only to describe the organization of attacks to a mirror, but to attempt to be able to predict the future behavior of the animal given its present behavior. (Peter Skaller)

1729-5N006 T Geology. Structure Analysis. The purpose of this investigation is to elucidate details of clay mineral transforms by one-dimensional structure analysis. This will be carried out by standard Fourier synthesis utilizing sine and cosine summations. The results of this study will be used in an attempt

to document in the laboratory, changes that many investigators have described from natural occurrences. The results should be of interest to many users and producers of clay materials. (Ray E. Ferrell)

1730-5N007 Department of Computer Science. Simulation of a Parallel Network Computer. This is the first phase of a long range study in parallel computation. A parallel network computer contains, besides a central memory and control, an array of processing elements, each one having its own arithmetic unit and data memory. All processing elements perform essentially the same sequence of operations (on different data) under the control of a program in central memory. The goal of simulating such a machine is to gain experience in the design and use of a parallel network computer, and specifically to set up guidelines concerning the following problems: 1) To determine what problems are suited for efficient computation of such a machine; 2) To determine what special features and in particular what instruction code are desirable for a parallel network computer; 3) To devise high level programming languages which can express the kind of parallelism of computation a parallel network computer can perform; 4) To identify and solve the problems of compiling and systems programming peculiar to a parallel network computer. (D. L. Slotnick)

1731-5N008 T Civil Engineering. Underground Openings. A finite element program for the stresses and displacements around openings in an elastic-plastic material has been developed. This research program will obtain computer solutions to compare with the actual behavior of some large underground openings. The program will be extended from the plane strain to the axi-symmetric case. (Ed Cording)

1732-5N009 Civil Engineering. Studies in Reliabilities of Indeterminate Structures. The prime user has developed a program for the reliability analysis of statically indeterminate structures based upon limit design. The purpose of this research program is to use the program for the analysis of typical indeterminate structures. The method is based upon a deterministic structure, probabilistic single load, and probabilistic resistance. The available program

is specifically for normal density functions. Since the negative region of normal density introduces certain difficulties in the physical interpretation of the results, it is intended to modify the program so that it could be used for Gamma density function. If time permits, it is intended to develop an optimization technique (based upon the reliability) by which a structure could be designed. (S. G. Haider)

1733-5N010 Civil Engineering. Probabilistic Approach To Some Structural Engineering Problems. A number of loading conditions considered in the design of civil engineering structures, such as wind loads, earthquakes, highway unevenness, and wave action on off-shore structures, are statistical in nature. Also, due to imperfections in the manufacturing processes, the resistance of structural members must be considered as statistical variates. Therefore, a rotational safety analysis of structures must be considered within the frame work of the theory of probability. This study will make exploratory studies to initiate a research program on the safety and reliability analysis of structures. The current areas of interest are: 1) Reliability models for indeterminate structures; 2) Statistical description of loading environments; 3) Analysis of random systems. (M. Amin)

1734-5N014 Agricultural Economics. Adjustments To Field Shelled Corn. This is a study of the production, harvesting, and marketing adjustments in the corn industry, as a result of the widespread change to field shelling corn. The objective is to determine the optimum facilities, equipment, and industry organization for maximizing efficiency in harvesting, conditioning, storing, transporting, merchandising, and processing corn. Computer facilities will be required in analysis of primary and secondary data using correlation, analysis of variance, and other statistical techniques. Some use will also be made of simulation models. (L. D. Hill)

1735-5N015 T Nuclear Engineering. Repetitive Pulsing. This research problem involves the study of the power and temperature histories of the Illinois TRIGA Reactor while pulsing at short time intervals. Theoretical models will be developed that represent these histories and that are in the form of differential integral equations.

The computer will be used to solve these equations and compare the results to experimental data. A percent error between the model calculations and the experimental values will then be found. (H. A. Kurstedt)

1736-5N016 Astronomy. Studies in Gaseous Nebulae. Several related problems pertaining to gaseous nebulae will be studied. The emission line spectra will be reduced to obtain radial velocities and line intensities outside the atmosphere. The blending of the lines of the Balmer series of hydrogen near the series limit will be studied to obtain information on collisional processes; this requires theoretical predictions as to what intensities to expect under different assumptions, for comparison with observations. Problems involving the kinematics and structure of the nebulae will also be studied, for comparison with the observed radial velocities. (James Kaler)

1737-5N017 Nuclear Engineering. Anemomometer Use in Compressible Flows. Data from anemometer systems is recorded on FM magnetic tape and replayed into an analog-to-digital conversion system. The digital output is placed on digital magnetic tape at low density. The low density tapes are copied at high density into a form compatible with FORTRAN programs. The data is then analyzed, utilizing standard statistical methods for determining means, higher moments, correlations, power density specturms, etc. (B. G. Jones)

1738-5N019 T Material Research Laboratory. High Pressure Data Analysis. The study of solids under pressure utilizes x-ray diffraction and the Mössbauer effect to determine pressure induced changes in the solid. A regression analysis of the raw data is necessary as well as further numerical work to relate the measured properties with the parameters of the material in question. Typically one analyzes a six line Mössbauer Spectrum to fit six lorenztian curves. Other times one has six or seven x-ray lines to give a crystal structure and lattice parameters. (H. G. Drickamer)

1739-5N020 T Civil Engineering. Box Girders. The work proposed will be the theoretical investigation of multiple cell box girder bridges. Stresses and deformations will be determined throughout the box girders. Effect of continuity over several supports and effect of diaphragms will be included. The procedure used will be a numerical integration (β method of Newmark) of a linear system of differential equations of the second order. STRESS language will also be used. (Sana Abdelsamad)

1740-5N021 Civil Engineering. Trip Distribution and Traffic Assignment. New techniques in the urban transportation planning field require analysis of large amounts of data which deal with the travel patterns of individuals and goods throughout the urban community. The Bureau of Public Roads has developed computer programs for use in vehicle trip distribution and traffic assignment problems which are encountered in the planning of urban street and highway systems. While the programs are written for use on the IBM 7094 equipment, they must be modified so as to be compatible with the computer equipment which is available at the University of Illinois. It is the intent to experiment with these programs to determine their value for use in research and incorporation into highway and traffic instruction. (R. R. Knox)

1741-5N022 Nuclear Engineering. Pulse Propagation. Numerical methods are used to study the characteristics of thermal neutron pulse propagation during a reactor pulse. The techniques used are fairly routine, e.g. a Fourier analysis of the pulse shape is carried out for various space points using standard methods to evaluate integrals; also various time and pulse width Fourier moments are defined and evaluated. The results can be used to evaluate cross sections for the medium through which the pulse is propagating. (G. H. Miley)

1742-5N023 Chemistry and Chemical Engineering. Rotary Spin Echo (1). Calculation of the effect of chemical exchange in liquids on rotary spin echo amplitudes will be done. The problem involves solving appropriately modified phenomenological Bloch equations which describe the motion of an assembly of magnetic nuclei in external magnetic fields. The resulting equations form a

set of six coupled, non-homogeneous, linear differential equations with constant coefficients. The method involves solving these equations numerically with appropriate boundary conditions, using a fourth order Runge-Kutta technique. (Neville Boden)

1743-5N025 Political Science. Optimizing Legal Policy. The project involves the testing of hypotheses concerning (1) variables that influence judicial and other policy decisions, (2) effects of alternative legal policies, and (3) the relevance of social science theory and method to law. The data comes from questionnaires, court reports and dockets, legal directories, statistical almanacs, and other sources. The data will be processed by SSUPAC library programs and by various FORTRAN and ALGOL programs. The mathematical methods mainly relate to correlation, regression, statistical significance, cross tabulation, and other statistical techniques. (Stuart Nagel)

1744-5N026 T Mechanical Engineering. Fluid Amplifiers. Fluid amplifiers are a recent development which can perform logic and control functions with no moving parts. The underlying principle of operation of most fluid amplifiers is that a fluid jet will attach to a wall placed adjacent to it. When two walls are present with proper proportions, it will arbitrarily attach to one wall and will remain attached if undistrubed. When a signal is fed in from the wall to which the jet is attached the jet will switch to the opposite wall. The output of this device is digital.

The nature of the present problem is to study the switching times of this jet as a function of geometry, jet velocities, and control fluids. The controlling mechanism in the present study is the viscous effect of the fluid. This effect can be integrated into the overall flow problem by using integral equations, which are solved by numerical methods on the computer. (D. E. Wollersheim)

1745-5N029 Chemistry and Chemical Engineering. Analysis of Gamma Ray Spectrum Data. Gamma ray spectrum data represents the energy and intensity of gamma radiation incident on a crystal detector. Each gamma ray energy peak in the spectrum is characteristic of a particular isotope. The intensity

of the peak is proportional to the amount of radioactive isotope present. In a complex spectrum several peaks representing the various isotopes are superimposed on each other forming a composite spectrum. By a least squares fitting of experimental data from single isotope data to the data of a composite spectrum, one can calculate the amount of isotope present in the composite spectrum by the following method. Let: i = Index of a particular energy region; k = Index denoting a particular single isotope spectrum; Y_{ik} = Relative intensity of the k^{th} spectrum in the i^{th} energy region; A_k = Intensity of the k^{th} spectrum; Y_i = Intensity of the composite spectrum in the i^{th} energy region. One then calculates the A_k's such that $\sum_i (Y_i - \sum_k A_k Y_{ik})^2$ is a minimum. A_k is proportional to the amount of isotope present. (J.L. Brownlee)

1746-5N030 T Educational Administration and Supervision. Educational Negotiation Index. An Educational Negotiation Index, consisting of 24 areas within which negotiation between teachers and boards of education might potentially occur, will be administered to 2300 teachers, board members, and school administrators. Respondents will rank the 24 areas in terms of the degree of negotiability perceived by the rater. Mean sum of ranks for each respondent group on each negotiation area will be compared via analysis of variance and t-test to measure significance of difference between perceptions of the primary groups. (Carl L. Midjaas)

1747-5N031 T Sociology. Elite Interchangeability. This project is an investigation of elite interchangeability in the United States as evidenced by frequency counts and measures of association between sixty variables in eight samples. The variables are designed to indicate the extent of similarity of social characteristics of the elites, their horizontal occupational mobility, and the occupations of their elite kin. The study bears upon problems of elite circulation and power structure. Two SSUPAC programs will be used: frequency counting and measures of association. The frequency program will be asked to prepare one and two way tables of frequencies as well as percentages of total and of column. The measures of association program will be asked to calculate chi-square, C,T, and gamma measures on selected pairs of variables. (Sidhu)

1748-5N032 Department of Computer Science. IBAL Translator. The program, written in NICAP, will be a translator from the Illiac III Basic Assembly Language (IBAL) into Illiac II machine code. It will have approximately four passes with thorough error checking. Its primary use will be for checking systems programming for the Illiac III, prior to the time that that machine is operational. (John Schwebel)

1749-5N033 T Physiology. Fourier Analysis of Physiological Waves. Electrical activity of the small intestine shows spikes which are associated with contractions and rhythmic slow waves of approximately 5 seconds duration. The slow waves are conducted at slow velocity and their point of origin may fluctuate in location. Sometimes the slow waves are nearly sinusoidal, but usually they consist of an initial fast negative component followed by a slow negative and final positive wave. It is proposed by Fourier analysis of the slow waves to ascertain whether the complex wave forms can be analyzed to indicate interaction from several coupled oscillators. (Joanne Tschopp)

1750-5N034 Psychology. Motivation, Animal Studies. A multivariate experimental design has been employed to collect measures of rat behavior of motivational relevance. Computer usage is required for: a) preliminary recoding and intercorrelation of approximately 100 subjects on 250 variables, from which groups of 50 variables will be selected for analysis; b) factorial resolution of at least two 50 x 50 matrices and one 100 x 100 matrix including rotation to simple structure; c) inclusion in the above of the experimentally manipulated living and feeding conditions of the animals and alternate forms of some variables via the Dwyen extension method, and/or an analysis of variance treatment by manipulated conditions of factor scores or selected variables. (Weiffenbach)

1751-5N035 Psychology. Light Choice Reaction Time Study. This study examines the relation of response uncertainty versus stimulus uncertainty to reaction time latencies. The study uses eight lights in a display panel which are connected in a mechanically variable mapping to eight response buttons. Information given subjects allows them to operate within 0, 1, 2, or 3 bits

of stimulus and response uncertainty. Stimulus to response uncertainty was varied within the half matrix such that response uncertainty was always $\leq$ stimulus uncertainty. In addition, subjects were required to make behavioral hypotheses (guesses) within these uncertainties as to which stimulus would appear. The hypotheses to be tested are: 1) Reaction time will be faster when subjects have made correct behavioral hypotheses; 2) Reaction time will vary as a function of total uncertainty in the condition; 3) Response uncertainty will account for more variance than stimulus uncertainty; 4) There will be no interaction of subjects and conditions (or uncertainty); 5) There will be no interaction of behavioral hypotheses and conditions. The analyses of the data from this study will require one 3-way analysis of variance and ten 2-way analyses of variance. (Schurman)

1752-5N036 T Psychology. Electroencephalographic Concomitants of Vigilance. Current research has shown man to be a better monitor of complex tasks than he is of simple tasks. The arousal hypothesis (Hebb, 1955) has been offered to account for these differences. The basic assumption of the arousal hypothesis (that vigilant monitoring occurs because of reticular formation activity) will be tested. Electroencephalographic (EEG) and behavioural measures will be obtained from subjects undergoing two levels of a typical monitoring task. One level will replicate a task historically found to produce vigilance decrement. The other level will replicate a task historically found to maintain vigilance. If vigilance is associated with reticular activity and subsequent cortical activity, the EEG measures will show these differences. The behavioural measures will show if the two task levels have successfully been replicated. The analyses will include three and four factor analysis of variance, product-moment correlation, and t test. (Thorsheim)

1753-5N037 Physics. K02 Meson Decays. The decay of neutral K-mesons into two and three particles is being studied by photographing the tracks made by the charged decay particles in a spark chamber inside a magnetic field. The positions of the sparks are digitized by means of a Hydel measuring machine or by an automatic scanning device. The computer must reconstruct the decay in real space and must analyze the decay in terms of the momenta and

angles of the decay products. The efficiency of detection of a decay as a function of the energy of the incoming K-meson and the angles of the decay products must also be calculated. (Lynn Verhey)

1754-5N040 T Marketing. A Study of Retailers' Attitudes Towards Watch Servicing. This study will be concerned with an investigation of the existing attitudes and needs for watch repairing services of retailers and watchmakers who own jewelry stores and comprise the American Watchmakers Institute. The computer will be used in this study to tabulate all data gathered by mail questionnaires. Frequency counts, frequency count tables, correlations, t-ratios, coefficients of correlation, etc. will be obtained. (Steven Isenberg)

1755-5N041 T Electrical Engineering. Surface and Leaky Waves in a Dielectric. The problem is to calculate the electric field generated by an infinite line source of current above and parallel to a dielectric-coated conducting plane. The method of solution consists of calculating an inverse Fourier transform by directly computing a contour integral in the complex plane. Since the desired function is not directly integrable, the technique of closing the contour and evaluating the desired integral by adding the residues at the enclosed poles and subtracting the integrals obtained along either side of a branch cut will be employed. A modification of Newton's method will be used to compute the location of the poles, and the subroutine RIEMAN for numerical integration, programmed at Argonne National Laboratory, will be modified to calculate the branch cut integrals. (G. Van Blaricum)

1756-5N042 T Education. Orientation and Effectiveness in Counseling and Social Work. The orientation inventory will be administered to a group of counselor and social work trainees three times during the school year. This inventory yields scores on three dimensions. Educators and supervisors of these trainees will evaluate them on a global scale of anticipated effectiveness in future professional activity. These evaluations will divide the trainees into three groups (top, middle, and bottom thirds). Means and standard deviations will be computed for these groups and the t test applied to the difference between means. Other variables include age, sex, prior experience, and undergraduate grade-point average. Frequency tabulations for each response will also be required. (Gordon A. Zich)

1757-5N043 Psychology. Associability Norms. 480 subjects were each presented 360 pairs of consonant-vowel-consonant trigrams varying from low to high meaningfulness. Each subject was instructed to give, if he could, an association that linked the two items in a pair. The analysis involved a binary classification for each subject by item pair, i.e., whether or not an association was given for that pair by that subject. The subject variable was then collapsed and frequency counts and proportions of subjects giving associations to each item were then determined. Separate analyses were run for males and females to determine possible sex differences for item pairs.

There were 172, 800 subject-item pair combinations. All frequency counting and subsequent analysis of variance programs are available on present SSUPAC routines. (Montague)

1758-5N044 Civil Engineering. Dynamic Response of Two Dimensional Structures to Blast Loads. The objective of the study is to investigate methods of evaluating the effects of gross inaccuracies in structure alignment and in soil resistance properties on the response of buried structures to nuclear blast loadings. The structure is approximated by a discrete system with the loads, masses and resistances concentrated at a finite number of node points. Variations in alignment and soil properties are introduced at the appropriate node points in patterns representing realistic conditions. Standard library routines will be used. (Terry O. Blackburn)

1759-5N045 Psychology. Psychophysics Methodology. Previously published information about the up-and-down method for sensitivity testing is relatively limited, and it is desired to determine by extended random sampling under the normal model, what the sampling distributions are for various estimators proposed under the method. It is necessary to examine these distributions as a function of size of scale step used in the sensitivity measurements. Of special interest are the distributions of (a) the estimate of the standard deviation, and (b) the estimate of the standard error of the mean. (Kappauf)

1760-5N046 Material Research Laboratory. Optical Constants and Dispersion Relations. The Kramers-Kronig dispersion relations will be used to obtain one optical constant in terms of the other, for example, the extinction coefficient K in terms of index of refraction n. This will have direct application to Faraday rotation data obtained in the laboratory for broad-line absorption, such as that due to F centers in alkali halide crystals. A computer analysis will give the momenta and change in moments of the line upon application of fields to the solid. The dispersion integrals will be evaluated by a trapezoidal approximation. (F. C. Brown)

1761-5N047 Theoretical and Applied Mechanics. Circle of Willis Hemodynamics. The circle of Willis is an arterial network at the base of the brain which serves as a distribution center for the flow of blood to the brain. This system has been modeled mathematically assuming steady flow and rigid vessels and the computer is used to solve simultaneously the energy and continuity equations that apply. Various modifications are made in the model, such as occlusive patterns which simulate pathological situations, in order to aid in the understanding of cerebral blood flow.

To aid in enhancing the model so as to include the attributes of pulsatile flow and flexible vessels prototype input impedance measurements on dogs and humans are being obtained from two collaborating laboratories. The Galesburg State Research Hospital and the Physiology Department of the Medical School of the University of Minnesota are both interested in this problem and will be obtaining measurements which need to be analyzed. The computer will be utilized to calculate appropriate quantities from the measured values and to then make Fourier analyses of the results. (M. E. Clark)

1762-5N048 Theoretical and Applied Mechanics. Methods of Altering Impedance in a Flexible Closed-Wall Fluid System. Impedance in a flexible, closed-wall fluid system is basically a problem in fluid mechanics. The problem involves unsteady flow conditions in a visco-elastic tubing system; more precisely, this study concerns the pressure to flow ratio, impedance, when these quantities have a sinusoidal variation with time. Predictions of impedance are made based upon valid assumptions and personal contributions.

Experiments are made to verify or refute the predictions and assumptions. A hemodynamics study requires the results of this investigation, since an alteration of fluid impedance is required in a model study of a portion of the blood distribution system located at the base of the brain of mammals. The computer will be used in both the experimental and theoretical aspects of the problem. (Michael Roller)

1763-5N049 T Chemistry and Chemical Engineering. Chemical Kinetics. The problem involves the calculation of rate constants for first order chemical reactions by means of a least squares fit to experimental data (natural logarithm of concentration versus time). Experimentally determined rate constants measured at different temperatures are then used to calculate activation enthalpies and entropies by means of the Eyring equation. The activation parameters are in turn used to calculate reaction rates at temperatures which are experimentally inaccessible. (W. A. Bernett)

1764-5N052 Electrical Engineering. Analysis and Synthesis of Musical Sounds. This project will utilize the IBM 7094, the Illiac II, and the CSX-1 computers for both synthesis and analysis of musical sound materials. This type of work is now made possible by the installation of high speed analog-to-digital and digital-to-analog converters and audio tape recorders at the Illiac II and CSX-1 installations. The Illiac II computer-D/A system is particularly well suited for the production of musical sound materials for use in compositions since it has the capacity for generating high fidelity audio signals for seven continuous minutes at the rate of 40,000 13 bit samples per second. This is equivalent to a 20 kc band width with better than 70 db signal-to-noise ratio. It is presently contemplated that the computation of the signal samples will be done in "time-share" mode and that these samples will be stored sequentially in alternative records on two digital magnetic tapes. These tapes will be read back in "disable-interrupt" mode and the samples will be converted and combined to form a real-time audio signal. The sound will depend on the mathematical functions which are specified for computation. Because of its high accessibility and capacity

for storing short sound segments (up to 5 seconds), the CSX-1 computer is particularly well suited for conversion of musical instrument tones into digital form. The digitized tones will be recorded on standard IBM tape at a density of 200 BPI. This low density tape can later be copied and converted to a more convenient 800 BPI version. The data on the tape can then be subjected to analysis by the IBM 7094 computer. Filters which accomplish the analysis are simulated within the computer and are designed by z-transform techniques. Once analytic data for the tones is obtained the tones may be resynthesized in terms of this data with the Illiac II computer-D/A system. (James Beauchamp)

1765-5N053 T Civil Engineering. Load and Stress Distribution in Gusseted Connections. The ultimate results which are desired are the load distribution in a line of fasteners in a gusset plate connection of specific geometry, and the resulting stress distribution in this plate. The connection is similar to a bridge hangar type. The method of approach will be to modify elasticity solutions for one fastener at various positions in an infinite plate and subsequently add these solutions to obtain a composite solution for stress distribution. The computer will also be used for computation of stresses along various sections of the plate. The standard library routine for the solution of simultaneous equations will be used to find the distribution of the load in the fasteners and to evaluate coefficients for series solutions of plane stress problems using a point matching technique. An alternate procedure which may be used is the solution of a finite difference network. (P. C. Birkemoe)

1766-5N054 Economics. Simulation Study. This is an attempt to simulate the growth of an economy with specified structural and behavioral characteristics in order to examine the effects on output and employment of different patterns of technical change. The computer will be used to generate the time path of the relevant economic variables starting from given initial conditions. (D. J. Harris)

1767-5N055 State Water Survey. Stream Flow Data Assembly. The computer will be used to assemble daily streamflow data, which is already on magnetic tapes, into a consolidated and orderly fashion for processing by a computer program under development. After the data is properly assembled, the monthly, yearly, and the record's mean value, standard deviation, maximum value, minimum value, and coefficient of variation will be found for every streamflow gaging station. The results will be used to design reserviors, watersheds and other water resources and flood control structures. (Robert Sinclair)

1768-5N056 Mathematics. Search for Simple Groups of Degree $p = 4q+1$, q prime. A complete knowledge of all minimal simple groups seems necessary to a full theory of groups and a major purpose of this investigation is to either discover new simple groups or prove the non-existence of any groups of this type for small degrees. Computations analogous to those used by Parker and Nikolar (A Search for Analogues of Mathieu Groups, MTAC (1958) pp 38-43) will be applied to groups of order $p = 4q+1$ with q prime. In general the computations are extremely time consuming. It is hoped that the advanced control and instruction register features of Illiac II will permit computations at least for $p \leq 400$. (Kenneth Appel)

1769-5N057 T Mechanical Engineering. Diesel Engine Combustion Analysis. This research problem consists of an analytical and experimental investigation of the high pressure spray characteristics, fuel air mixing, and diffusion flame phenomena in a highly turbo-charged pre-chamber compression ignition engine. The detailed analysis of the high-speed compression ignition considers the effects of dissociation, finite reaction kinetics, and irreversibilities such as heat transfer and mechanical friction on cycle performance and efficiency, and provides a highly flexible tool for investigating the complex relationships among engine variables. The resulting mathematical model and the related computer program offer a substantial computational advantage over previous methods that employ charts and graphs and require a large amount of manual calculations. The computer will be used for data reduction and analysis of combustion phenomena. Normal machine functions will be employed and no special subroutines will be required. (E. K. Buchholz)

1770-5N058 Vocational and Technical Education. Rural Education - Disadvantaged Youth. The purpose of the project defined in its simplest terms is to generate an effective vocationally oriented educational program that will bring about the full utilization of the present and potential capabilities of rural youth who are economically and socially handicapped. The end result will be that some disadvantaged rural youth will utilize vocational education opportunities to prepare themselves for gainful employment outside their communities, while others will utilize their developing vocational competence to improve the economic and social situation in their rural communities.

Three primary objectives of the project are (1) to study in depth a selected depressed rural area to identify the anthropological, economic, psychological, and sociological conditions and trends that typify the area; (2) to develop and conduct a "model" preparatory and supplemental vocationally oriented education program, specifically designed for members of disadvantaged rural families, which will lead to gainful employment of youth; and (3) to evaluate through an experimental treatment the "model" program in terms of the processes used and the results obtained and develop guidelines for vocationally oriented education programs that various types of communities may use to attack the educational problems of disadvantaged rural youth.

A descriptive analysis will be used to report the findings of the depth studies of the selected rural community and its inhabitants as well as to report observations made throughout the project.

The analysis of covariance statistical model will be used in the analysis of interval scale data while the chi square model will be used to test significance for noninterval data. (Lloyd J. Phipps)

1771-5N059 Chemistry and Chemical Engineering. The Effect of Thermodynamic Variables on Reaction Kinetics. A statistical mechanical description of a reacting mixture yields important information on the effects of various thermodynamic variables on the rate of the chemical reaction. For example, for a homogeneous gas phase reaction, there is a pressure-induced shift in the apparent rate constant due to thermodynamic nonideality of the gas phase.

The purpose of this study is to attempt to predict such a shift in the rate constant due to variations of the various thermodynamic properties, and compare the results with experimental data. The computer will be used both for the reduction of experimental data to find rate constants and to carry out the complex calculations required for the statistical mechanics prediction. (C. A. Eckert)

1772-5N060 Social Work. Mental Health Community Study. This is a community mental health study with before-after design which will be conducted over a period of six years. Changes in public knowledge and attitudes, knowledge and actions by community professionals, and experiences of mental patients will be examined as these relate to the establishment of the new Illinois Community Mental Health Program.

The research problem is an analysis of survey data collected through interviews with samples of the general public and of community professionals in two Illinois counties, and also data about individual mental patients in terms of selected characteristics. All three bodies of data will be analyzed to determine comparison between the counties and change over time, using standard techniques which in a large part will be available from SSUPAC. (M. Taber)

1773-5N061 T Electrical Engineering. Electro-magnetic Fields in a Lossy Dielectric. This problem involves finding the electric and magnetic fields in a grounded slab of lossy dielectric due to a magnetic line source on the dielectric surface. Laplace transform techniques are used. Much of the computer work will be to evaluate a closed contour integral in the complex plane using numerical techniques to locate the poles of the integrand and to sum the resulting residues. (Larry S. Nixon)

1774-5N062 Chicago Circle Chemistry. Molecular Quantum Mechanics. The problem is concerned with the development of new computational methods in the general area of molecular quantum mechanics. The final goal of this problem is the simultaneous incorporation of self-consistency criteria and the fitting of calculated to experimental results. In addition to utilizing

standard matrix routines, including the diagonalization of large matrices with non-orthogonal basis sets, the problem will make use of a large non-linear estimation package which has been written and tested elsewhere. (Thomas H. Brown)

1775-5N063 Chicago Circle Geology. Crystal Structures of Salt Hydrates. The project involves crystal structure analysis of salt hydrates using x-ray diffraction methods. The programs used are standard crystallographic programs for: Fourier synthesis, structure factor calculation, least squares refinement, data reduction, calculation of interatomic distances, and electrostatic energy calculation. (Baur)

1776-5D001 Civil Engineering. N/C Drilling for Standard Connections. It is desired to design a program to convert a description of a bolted or riveted structural steel framing system into control data that can direct either a numerically controlled drilling machine to drill the necessary holes in the individual members, or a plotter to produce shop drawings of the members. Eventually this program will become an output routine for STRESS, the integrated structural design program. The program itself is meant to demonstrate that the computer's role in structural design can be extended to control shop fabrication, or, if desired, to generation of detail drawings. (F. Hatfield)

1777-5D002 T Material Research Laboratory. Calorimeter Data. It is desired to evaluate the enthalpy of allotropic phase transformations in metals and alloys whose transformation mechanisms are being studied. The computer will be used to convert calorimeter emf data to heating rate data and to estimate limits of error. The results will be used to plot continuous specific heat functions and to evaluate the desired enthalpies. (R. E. Adams)

1778-5D003 Electrical Engineering. Correction of Distribution Functions. In a study of tissue cell size distributions it is necessary to correct the experimentally observed distributions for fragments of cells produced during sectioning. A program is available which accepts experimental data on cell sizes from a given tissue section, sorts them into size intervals, and

proceeds with a step wise method of adjustment of the distribution. First, the fraction of cells in the i^{th} size range (diameters D_i to D_{i+1}) which contribute fragments to a smaller size interval (D_j to D_{j+1}) is calculated. Beginning with the interval representing the largest cells, this quantity is used to remove from each smaller interval the number contributed by fragments of the larger cells. (Jeannine Leichner)

1779-5D004 State Water Survey. Isentropic Analysis. This program uses radiosonde data, i.e., temperature, pressure and relative humidity at various elevations, as input and calculates the Montgomery steam function, pressure, virtual temperature, relative humidity, mixing ratio, saturation mixing ratio and absolute potential temperature at standard levels of potential virtual temperature and at the surface. These standard levels are selected at five degree intervals of Kelvin temperature. In addition the program reads in reported wind data and interpolates in order to get values of wind speed, azimuth, and component velocities at these same standard levels of potential virtual temperature (isentropic levels). A table of the radiosonde data used as input, including the corresponding winds, is also included in the program's output. (Pieter Feteris)

1780-5D005 State Water Survey. Thomasell Area Volume Precipitation. This problem utilizes a program, developed by Thomasell at the Travelers Research Center, which serves to expedite routine computations of rainfall-depth-area relationships and the total volume of water deposited on a large size mesonet area with irregularly spaced stations. Both parameters are a measure of the efficiency of precipitating systems and will be related to various other meteorological parameters. The method compensates for variable data density and can be expanded to use independent verification data and estimate of the mean error of the entire analysis. (Pieter Feteris)

1781-5D006 State Water Survey. Windshear. An indication of the direction and spacing of the isotherms over radiosonde stations is essential for a correct analysis of temperature fields on constant pressure surfaces. These data can be evaluated from the thermal wind relationship for a constant pressure surface:

$$\left(\frac{\partial T}{\partial y}\right)_p = -\frac{fT}{g}\left(\frac{\partial U}{\partial Z}\right)_{xy} \text{---(1)}; \quad \left(\frac{\partial T}{\partial x}\right)_p = \frac{fT}{g}\left(\frac{\partial V}{\partial z}\right)_{xy} \text{---(2)}$$

where T is the absolute temperature; f the coriolis parameter; g the acceleration of gravity; u and v the wind components in the x and y direction; and z the height. The program has built-in corrections for accelerations due to curvature of the streamlines and a smoothing operator for eliminating random fluctuations of the wind. The program also predicts six-hour temperature changes which are necessary for interpolation of displacement and trend of temperature patterns for intermediate hours when temperature data are missing but wind observations are available. (Pieter Feteris)

1782-5D007 Physics. Least Squares Fit to Mössbauer Spectra. The Mössbauer effect is being utilized to study various physical problems, for example, the properties of atoms situated on solid surfaces. J. W. Burton has written a program which will be used to perform a least squares fit to a sum of Breit-Wigner Mössbauer resonance lines. (Debrunner)

1783-5D008 T Mining, Metallurgy, and Petroleum Engineering. Contact Stresses in a Cracked Beam. Photoelastic studies are being made of the contact stresses around cracks in self-loaded beams. Interior stresses will be calculated by the computer program from the photoelastic data. The program will use the shear-difference method for calculation of the stresses. (M. B. Mirza)

1784-5D009 T Mining, Metallurgy, and Petroleum Engineering. Multiple Decay Analysis. The computer will be used to analyze experimental data for the elastic after-effect in metals. The analysis consists of decomposing the experimental relaxation data into distinct exponential components. The

first part of the planned program is to test the available computer program by feeding in computer generated data. The second part will consist of the actual analysis of the experimental data. (Robert Hoffman)

1785-5D010 Chemistry and Chemical Engineering. Least Squares Fit-Atom Transfer. Values of standard Gibb's free energy of reaction and Gibb's free energy of activation for series of related atom transfer reactions will be calculated from equilibrium and rate data. These energies will then be compared with both straight lines predicted by the Brönsted relationship and parabolas predicted from a theory recently derived for electron transfer reactions. (Audrey O. Cohen)

1786-5D011 Civil Engineering. Design and Contracting of Reinforced Concrete Buildings. The goal of this project is to develop a system which automates the design and contracting of reinforced concrete buildings. The basis for design will be the ACI Building Code and both working stress and ultimate strength designs will be incorporated. Linear optimization will be used for member proportioning and provisions for alternate proposals will be included. The design will be followed by a quantity take-off and the determination of a Critical Path Schedule. Hence, using a wage, material, and equipment rate table, the contract bid will be prepared. (R. K. Kinra)

1787-5D012 Anthropology. Genetics of Structured Populations. The problem under study is that of the population genetics of structured populations, i.e. populations in which mating is not random. The available algebraic models for the study of population genetics are limited in their utility to either randomly mating or highly rigid mating systems. In contrast, the constraints placed on mating in human and many nonhuman populations give rise to weakly ordered systems which may be best studied through computer simulation. The purpose of this research problem is the development of such a simulation program for the IBM 7094. After an initial testing of a series of hypotheses about structured populations it is hoped that the program can be altered or expanded to simulate particular real populations. (R. Reid)

1788-5D013 T Agricultural Economics. Spatial Equilibrium and Minimum Absolute Deviation Estimation. The linear programming routines, LP/90 and SSUPAC will be used 1) in the estimation of models depicting the optimum regional levels of production, price and geographical flows in the feed-livestock sector and 2) in deriving the sampling properties of minimum absolute deviations estimators. (D. Arnold)

1790-5D015 Political Science. Presidential Election Analysis. Students will be engaged in secondary analysis of Michigan Survey Research Center data on the Presidential elections of 1952, 1956, 1960, and 1964. The computer will be used for computing correlations and cross-tabulations based on a variety of hypotheses on the relationships between personality and selected political variables. Standard SSUPAC routines will be used. (Denis G. Sullivan)

1791-5D017 T Nuclear Engineering. Pulse Propagation in Multiplying Medium. The neutron pulse propagation in multiplying media is studied with the help of an age-diffusion model. The purpose of the experiment is to develop a new technique for measuring the reactivity of the multiplying medium. Analytical and numerical solutions will be computed and compared with the experimental results. The diffusion equation will be solved by using standard subroutines already available. (P. Doshi)

1792-5D018 Civil Engineering. The Effect of Rainfall Distribution on the Runoff. The time distribution of rainfall of any predicted storm has a great effect on the runoff hydrograph which is computed by means of the unit hydrograph method. Kulandaiswamy proposed, in 1964, another method of relating runoff to rainfall, that is by the storm equation. The purpose of this research is to find the effect of rainfall distribution on the runoff hydrograph computed by means of Kulandaiswamy equations. (Benzvi)

1793-5D019 Civil Engineering. Gamma Ray Interface Calculations. There are several problems involving description of the gamma ray exposure field near an earth-air interface, or other interfaces of interest. Some of these will be studied as follows: a) Fitting of various empirical formulas to Monte Carlo results on gamma ray albido. This will be accomplished by straight-forward least squares technique. b) Monte Carlo calculations of the exposure field above the interface for various source configurations. Procedures will be optimized for each situation studied. (A. B. Chilton)

1794-5D020 Civil Engineering. Criteria For Analysis of Water Distribution Systems. This problem is an extension of work done over the previous two years. One of the previous problems was a study of power requirements and pump performance for simulated operation of a water distribution system served with elevated storage. In the present study, a booster pumping station with ground storage will be used in place of elevated storage. The objectives are the same: to study power requirements and pump performance. As for the elevated storage study, hourly system demands for a full year of actual data will be used for two different systems and a number of operating options will be investigated. One of the most important outcomes will be a comparison between the results for the two types of systems, elevated storage and booster pumping with ground storage. (M.B. McPherson)

1795-5D021 T Civil Engineering. Lateral Boundary Problems Associated With a Confined Soil Mass. Shear forces which exist at the interface between a confined soil mass and a container have plauged researchers who have studied pressures in soil masses confined in bins. The purpose of this problem is to develop a mathematical model which can be used to study the effect of shear forces on the distribution of stress over a cross section of a confined soil mass subjected to a vertical pressure pulse. The computer will be employed to solve the equations of motion by numerical methods, since a closed form solution does not exist. (J. D. Prendergast)

1796-5D023 T Chemistry and Chemical Engineering. Nuclear Magnetic Resonance Line Shapes. Nuclear Magnetic Resonance (NMR) can be used to determine the rates and activation energies of fast chemical exchange reactions. For example, the proton NMR spectrum of trimethylaluminum plus lithuim tetramethylaluminum in ether consists of only one resonance at room temperature and two resonances at - 50°C, indicative of fast and slow methyl group exchange, respectively. The line shape between these two extreme temperatures is critically dependent upon the rate of methyl group exchange. By comparing calculated line shapes with experimental spectra, the rate of each temperature can be determined, and thus yield an activation energy for the process. Equations describing the NMR line shapes of exchange systems involving two or more sites can be derived from the Block equations. Even in a two site system the completely generalized equation is rather long. The equation gives the amount of intensity at a given value of the field strength. In order to obtain the complete line shape, it is necessary to evaluate the intensity at many values of the field strength. (K. C. Williams)

1797-5D025 T Psychology. Somatic Preference. Following a procedure developed by Professor Tucker, this problem involves the multidimensional scaling of paired comparison judgments of stimulus differences in such a manner as to isolate dimensions of individual differences in such judgments. The basic data matrix is comprised of the sums of squares and cross products of all judgment pairs. This matrix is reduced by the method of principal components and transformed by the oblimax procedure. A matrix of stimulus loadings or retained components is obtained by premultiplying the reduced matrix by the original data matrix and postmultiplying it by the inverses of the eigenvalue matrix and the oblimax transformation matrix. Columns of this matrix are rearranged to form interstimulus distance matrices which are subjected to multidimensional scaling procedures involving principal component analysis. Additional analyses are then performed on the transformed subject matrix which involve the multiple regression of additional variables on the columns of the subject matrix. All of these operations are available in SSUPAC. (Judy Cohen Conger)

1798-5D026 State Water Survey. Lake Bloomington Water Quality Study. A sampling plan is in operation to obtain data on the alkalinity, temperature, pH, nitrates, phosphates, CO_2, and aquatic organisms of Lake Bloomington water at several depths for seven transects across the lake. Bottom samples are also collected for alkalinity, manganese, temperature, pH, organisms, organic content, and soil description. Other variables involved in the project are precipitation, streamflow, air temperature, and tributary data. The horizontal, vertical, and seasonal variation of the data will be studied. Computer programs for X, Y scatter diagrams, correlation and regression analysis, frequency analysis, and time series analysis will be used in the data analysis. (Ralph Evans)

1799-5D028 T Chemistry and Chemical Engineering. Crystal Structure Analysis. The utilization of the computer in crystal structure analysis is founded on the necessity of summing Fourier Series. Any quantity that is a periodic function of a single coordinate X can be represented by a Fourier series

$$F(X) = \sum_{n=o}^{\infty} A_n \cos 2\pi \, (nX/a + b_n)$$

where A is the amplitude of each cosine wave, b is the phase angle and a is the repeat distance. The density of scattering matter within a crystal is a periodic function in three dimensions, and one can represent the electron density by a triple Fourier series

$$d(xyz) = \sum_{-\infty}^{\infty} \sum_{-\infty}^{\infty} \sum_{-\infty}^{\infty} A_{hkl} \cos 2\pi \, (h\,x/a + ky/b + lz/c).$$

The amplitudes A_{hkl} are obtained by measuring the intensities of the x-ray beams diffracted by crystal planes with indices h, k, l. The repeat distances a, b, c correspond to unit cell dimensions of the crystal. Several thousand intensities are utilized in drawing up the density map. Programs are available to perform the summations of series described above. Auxilliary programs will also be utilized to correct raw experimental data for use in the amplitudes. (J. A. Stanko)

1800-5D029 T Aeronautical and Astronautical Engineering. Characteristic Analysis of Rocket Exhaust Plumes. The method of characteristics will be used to integrate the governing equations of axisymmetric motion in the supersonic portions of the plume behind an underexpanded, conical nozzle. Viscous mixing will be included in the analysis. An analysis will also be made in the subsonic regions (using some suitable method) of the plume. No calculations will be performed downstream of the first minimum jet diameter. Analyses will be run for both quiescent and supersonic external streams. Special attention will be paid to the location of the first Mach disc and to the interaction of this Mach disc with the intercepting shock. (R. Gilbert)

1801-5D030 Civil Engineering. Outrunning Ground Shock Calculations. Calculations are to be performed for the prediction of ground motions and stresses induced by nuclear bursts. Both the close-in effects and the outrunning effects will be considered. The problems will be formulated on the basis of lumped-parameter discrete models of soiled media; solution of the resulting equations will be performed numerically. (N. M. Newmark)

1802-5D031 Animal Science. Phosphorus Utilization in Pigs. The utilization of phosphorus by pigs is being studied as it is influenced by source and level of phosphorus and by various chelating agents. Utilization is determined by measuring blood and bone phosphorus levels and balance data (i.e., intake, urine and fecal values). Other mineral values are determined concommitantly with phosphorus to evaluate importance of mineral interrelationships in comparing phosphorus sources. The data is to be analyzed by the method of least squares. (B. G. Harmon)

1803-5D032 T Civil Engineering. Propagation of Elastic-Plastic Waves in a Dispersive Rod. The study will be concerned with the propagation of elastic waves in a semi-infinite circular rod subjected to pressure and displacement inputs at one end. The material of the bar will be assumed to be: (i) Elastic-perfectly plastic, or (ii) of the Coulomb-Mohr type. Both the longitudinal and lateral motions of the solid will be considered; the problem then is one of axially symmetric geometry. An appropriate axially symmetric discrete model will be used in the formulation. The solutions will be determined by numerical quadratures. (A. H. Sameh)

1804-5D033 T Theoretical and Applied Mechanics. Minimum Weight Design of Shells of Revolution. The object of the proposed research is to develop a procedure for designing shell structures of minimum weight. Within the class of shell structures that may be selected for a given situation, there are obviously some shapes which are more efficient than others. The specific problem to be considered is that of determining the shape and thickness of the shell of revolution whose weight is minimum in the class of shells which will support a given axially-symmetric loading. The computer will be needed to calculate the weight of each proposed shell. To calculate the weight the shell thickness must first be determined by solving a system of equations consisting of five first-order ordinary differential equations and one algebraic equation. After the shell thickness is determined, Simpson's rule can be used to evaluate the integral expression for the weight of the shell. (H. D. Keith)

1805-5D034 Psychology. Scoring Program. Non-intellective factors influencing grade point average will be investigated. This program is designed to score two objective tests with dichotomous response options. The individual items and total scores of each scale are then correlated with an extra variable (grade point average). Additional analysis will include comparison of item endorsement percentages in high and low grade point average groups. (Peter C. Simmons)

1806-5D035 Electrical Engineering. Complex System Simulation. To aid theoretical and practical cybernetics work structures of interconnected elements are constructed and their behavior investigated. Computer simulation techniques will be employed to generate random structures of 100 elements. All inter-element connections are independent and equiprobable. Out of the 2^{100} one is selected and under a predetermined transformation a trajectory of states is generated. Measures such as Hamming distance, fluency memory, hesitancy, trajectory length, etc. are recorded and printed out. (P. D. Kinias)

1807-5D036 T Psychology. Attitudes Toward Psychotherapy. The purpose of this study is to investigate the attitudes, beliefs and behavior of 100 college students concerning "psychotherapy" and related concepts. Semantic differential scales were used to determine attitudes (A) and beliefs (B) regarding the characteristics and implications of "psychotherapy" and "psychological counseling". Three behavioral measures were used: (1) previous experience as a client; (2) evaluation of brief case-histories; (3) response to a letter from the student counseling service. For each subject, attitude scores for each concept will be estimated from the formula $\sum_{i}^{N} (Bi \cdot Ai)$. Correlations among the concepts presented and among the attitude and behavior measures will be computed. Standard SSUPAC routines will be utilized. (Rhoda Grossman)

1808-5D037 T Agricultural Economics. Financing a Low Equity Dairy Farm. Low equity farms have problems in financing their business. This research has as objective to study the influence of the repayment terms of a mortgage loan on the production organization and income earning ability of a dairy farm. More specifically the influence of the length of the mortgage loan, of the timing of the payments within the year, and of the number of payments within the year, on the production organization and income potential of the farm is studied. In addition reactions of lenders for short term credit on different repayment termsof a mortgage loan are assumed and alternately entered into the basic model to see the consequences with respect to production organization on and income earning capacity of the farm. Once we have a basic LP model all these variants can alternately be entered. (J. Vandeptte)

1809-5D038 T Mining, Metallurgy, and Petroleum Engineering. Study of Aluminum Industry in Panama. The problem consists of determining all the engineering and economic aspects which will affect the establishment of an integrated aluminum industry in Panama, reviewing the existing conditions and laying out the recommendations for the location, types of installations and capacity. The computer will be used in the solution of the following aspects of the problem: 1. Statistical analysis of the ore sampling information. 2. Regression and correlation analysis, particularly those related to the forecasting of supply and demand schedules. 3. Costs of production for different conditions. (Jorge Quiros)

1810-5D039 United States Geological Survey. Flood Flows from Small Drainage Areas. Within the past few years there has been great progress in the development of the hydraulic principles of flood-flows through culverts. These principles may be readily applied to culvert design with a view of obtaining required hydraulic effectiveness at minimum cost. However, the required hydraulic effectiveness is, in part, a function of the maximum rate of discharge at the culvert site. In order that these principles of design may be effectively applied, data concerning the magnitude and frequency of floods from small drainage areas in Illinois have been collected. It is the purpose of this problem to utilize these data and reconstruct mathematical models for estimating floods of given return periods. Since many of the physiographic and hydrologic properties of watersheds are of a multivariate nature, multivariate statistical techniques will be used to analyze these data. The collection of IBM 7094 computer programs prepared by the Statistical Service Unit will be used extensively. (USGS WRD)

1811-5D040 Education. Dogmatism in Social Studies Teachers. The study will explore the correlation of teacher's dogmatism with two factors: first, view of history, for which the Dogmatism Scale (Rokeach) is used as the central measure, together with items designed to describe a respondent's view of history; and second, psychological proximity to students. The Dogmatism Scale is administered to teachers and to their students. Teachers identify those students to whom they relate most positively. Is there a positive correlation between the D-scores of a teacher and these positively identified students? (Girault)

1812-5D041 Economics. Two-country General Equilibrium. The problem consists in finding numerical impact multipliers in a two-country general equilibrium model of international trade. The mathematical model has been completely specified and solved. Finding the impact multipliers will greatly enhance the illustrative value of the model. No computational difficulties are anticipated, as the model is linear, but the size of the model necessitates computer use. (Hans Brems)

1813-5D042 T Chemistry and Chemical Engineering. Vibrational Energy Transfer in Collision Problem. The vibrational energy transfer as a result of a collision between a diatomic molecule (harmonic oscillator) and an atom is calculated using an approximation for the potential energy function which minimizes the potential energy of interaction and which has a time dependent expression for the force constant. The solution for the equations of motion of the center of mass coordinates in this system is to be computed by numerical quadrature (trapezoid rule). Classical and then semi-classical calculations are undertaken in this problem. (Mary Attermeyer)

1814-5D043 T Psychology. Kent-Rosanoff Study. This study is designed to investigate the relationship between responses to the Kent-Rosanoff word association test and a) the effects of sex, speed instruction and "ego-involvement" instructions and b) certain personality characteristics of respondents. The sample size is 360, consisting of 240 subjects (college students) and 120 psychiatric patients (schizophrenics). The facilities of the department computer service lend themselves to an efficient analysis of the data because of the number of subjects (360), the number of variables (12), all of which have two digits, and the number of statistical analyses planned (approximately 20). Specifically, the predominant method of data analysis will be analysis of variance, although several correlations will be performed when the correlational approach is the only and/or most feasible method available. (R. Breitmeyer)

1815-5D044 Bureau of Economic and Business Research. Illinois Interregional Trade (manufacturers listing and analysis). The nature of this problem is to prepare a mailing list of Illinois manufacturing establishments from which a stratified sample can be taken. Since the data are not currently in the appropriate order, the computer will be used to sort and place them in the following order: All establishments will first be separated by 4 geographical regions; within each region the establishments will be grouped sequentially according to their

Standard Industrial Classification number (SIC); within each SIC group the establishments will be arranged within employment size categories. Finally, a stratified sample will be selected to include all establishments larger than a given employment size and a certain percentage of all smaller establishments. Special listings will also be made of all headquarters and their Illinois branches. The basis for the sequencing of this listing will be identification number only. For working purposes up to 10 copies of these listings will be required.

A supplement to these listings will be frequency distribution tables indicating the number of establishments within each employment class for each SIC group within each of the 4 regions and for the state as a whole.

Finally, programs will be written to utilize the computer facilities to process the data collected including regression and variance analyses with other standard statistical tests. (John W. Allen)

1816-5D046 T Aeronautical and Astronautical Engineering. Gas Kinetics. An attempt will be made to investigate the flow characteristics in the Knudsen layer near a solid surface of an aerodynamic problem. The governing partial differential equations, developed from the kinetic theory, will be numerically solved by a finite difference method. The flow properties, determined from the moments of the distribution function obtained, will be parametrically dependent upon the surface properties and this parametrical dependence will also be investigated. (H. J. Schmidt)

1817-5D047 T Theoretical and Applied Mechanics. Distribution of Stresses on Concrete Bridge Slabs. A study of stress distribution and their effects on scaling of concrete bridge decks. The study will try to locate the areas on the bridge deck surface where stresses (tensile and compressive) will have a maximum value as far as the scaling of concrete is concerned. The computer will be used in evaluating the positive and negative moments in different regions of the deck due to various kinds of truck loading, and finally evaluating the stresses at these points. (M. H. Rejali)

1818-5D048 Material Research Laboratory. Impurities in Metals. (2) As in Problem Specification 5Ø092. The effect of an impurity on the wave function of an electron in a metal is calculated, using the Schrödinger equation and the known potential of the impurity. The mathematical technique used for solving this second-order differential equation is the Noumerow technique. (M. A. Ball)

1819-5D050 Civil Engineering. Statistical Analysis of Fatigue Data. Regression analysis of fatigue data from tests on soil cement mixtures. Fatigue data of stress level and number of load application to failure were obtained from repeated load tests. The purpose of this problem is to find the line of regression and residues of these data. (Shu-Yin Yu)

8.2 Instructional Problem Specifications

During the last quarter of 1965, 19 instructional problem specifications were submitted to the department for computation. The following brief descriptions of these problems have been prepared for inclusion in this report by those submitting them.

I221-50001 Agricultural Economics 325. Problem No. 1. Teaching Linear Programming. Small problems are to be assigned in Agricultural Economics 325 to teach the rudiments of linear programming and the use of the computer in programming such problems. Mathematically the problem is to maximize P'X subject to $X \geq 0$ and $A X = Q$ where P,Q and X are vectors and A is a matrix. (J. T. Scott, Jr.)

I224-5∅013 Mechanical Engineering 421. Air Conditioning System Performance. The performance of a system will be predicted when the performance of the individual components is known. The performance of the components will be expressed in a linear or parabolic equation and the computer used to solve simultaneous equations by iterative techniques. (W. F. Stoecker)

I225-5∅012 Mechanical Engineering 259. Vapor Compression Refrigeration. The computer will be used to develop a second or third order equation to represent the performance of a refrigeration system. (W. F. Stoecker)

I231-5∅029 Theoretical and Applied Mechanics 428. Problem No. 1. Nonlinear Mechanics. Nonlinear problems will be solved for systems having from one to twenty degrees of freedom with various nonlinear springs and damper characteristics under steady state, transient, and random excitations. (W. J. Worley)

I232-5∅030 Anthropology 490. Problem No. 1. Genetic and Genealogical Analysis of a Mexican Village. This problem involves an analysis of the frequency distributions of the alleles studied as a function of Barrio, position, and occupation. A regression of this information may be attemped. The genealogical analysis will include both a genetic analysis by family, and later a study of marriage patterns. Most of the programs will be written in SCATRE so that the list processing procedures can be most conveniently incorporated. (E. Giles)

I233-5∅031 Astronomy 401. Model Stellar Atmospheres. The problem is the construction of a model stellar atmosphere, i.e. the determination of temperature, pressure, etc. as a function of depth in the atmosphere of a star. The procedure involves several iterations, and a number of numerical integrations. (James Kaler)

I235-5∅040 Electrical Engineering 389. Problem No. 1. Receiver Design Problems. The problems which are to be put on the computer are part of a larger problem of designing a radio receiver. One of the problems consists of gain calculations over a specified band of frequencies. The same operation is repeated many times. The other problem consists of calculating the points for a tracking curve in which certain specified values are given and by means of simple algebraic manipulations the actual intermediate frequency is calculated. (P. F. Schwarzlose)

I236-5∅041 Department of Computer Science 397. Problem No. 1. Various experimental programs, employing classification methods and the generation and syntax analysis of natural languages, will be written. (S. R. Ray)

I237-5∅046 Aeronautical and Astronautical Engineering 221. Problem No. 1. Multicell Torsion Tube Analysis. The shear stresses in a multicell torsion tube may be found from a set of simultaneous equations. The torsion tube will represent a modern aircraft wing cross-section. The library routine "MATINV" will be used to solve this set of simultaneous equations. The solution is similar to the current method used in the aircraft industry. (Curtis F. Vail)

I238-5∅047 Nuclear Engineering 456. Nuclear Engineering 456 is a course in Advanced Reactor Physics. It is an intrinsic part of the course to familiarize the graduate students with digital computer approaches to the solution of relevant neutron transport problems. To this end, students will use or extend existing codes such as the SNG code, Multigroup codes, or codes to evaluate neutron cross sections. (F. T. Adler)

I252-5Ø087 Economics 294. Problem No. 2. The class problem will require statistical analysis of certain areas of various economies. Least-squares regression techniques will be used. Since many of the analyses will be based on a large number of observations (in some cases in excess of two hundred) hand calculation is impractical. (C. M. Sprinkle)

I256-5N011 Civil Engineering 366. Problem No. 1. Behavior of Reinforced Concrete Members. The following two programs are available to study the behavior of reinforced concrete members: 1) A general program for determination of load-deflection relationship for a simply supported beam. The program applies to any stress-strain diagram for concrete and steel, any section and any type of static short time load. 2) A program for obtaining the interaction diagram at failure for reinforced concrete columns subjected to bending. The program is specifically for rectangular sections, elasto-plastic stress-strain diagram for steel and parabolic-linear stress-strain diagram for concrete.

These programs will be made available to the students after they have mastered the theory and are able to solve the problems manually. The program will be used to study the influence of all the variables on the shape of the load-deflection diagram for beams, and the interaction diagram for columns subjected to bending. (C. P. Siess)

I258-5N013 Aeronautical and Astronautical Engineering 262. Single Stage Ejector. The problem is to find the mass flow field of two interacting streams, one supersonic and one subsonic. The supersonic flow field is found by the method of characteristics and the subsonic flow field is found by an isentropic pressure area relation. An iteration is needed to find the pressure ratio between the two streams such that the subsonic flow is just chocked. This is part of a staged ejector optimization. (J. L. Loth)

I259-5N018 General Engineering 242. Problem No. 2. Designing a Semi-Automated Workstation Plus Some Simulations. The computer will be used in conjunction with other analysis tools by students in a senior project design course. The simulations will require new programs to study a traffic flow problem. The workstation design will use existing or modified programs to analyze capacity requirements and to evaluate alternate designs.
(D. E. Scheck)

I263-5N038 Economics 402. Problem No. 1. Estimation of Simultaneous Relationships. One type of simultaneous interaction frequently arising in economics involves the interaction of supply and demand forces in a market that generate observed data. A demand function (in this case for primary and secondary education) which has been derived mathematically from a utility function and budget constraint, together with a supply function which has been derived from a production function and cost constraint, are fit to data for the U.S. for the 1947-65 period using a two stage least squares regression library program. (Walter W. McMahon)

I264-5N039 Sociology 184. Sociological Research Methods. Each student will run tests on a problem or hypothesis of his own which will involve data collected jointly by all members of the course. The general problem deals with adults' views on vocational-educational opportunities available to young people in contemporary American society. Statistical treatment of data will be limited to those in the SSUPAC program package. (Gene F. Summers)

I268-5D022 Nuclear Engineering 349. Class Problem. The computer will be used to solve a problem related to radiation protection. The problem involves the use of Monte Carlo techniques for determining the backscattering of gamma and x-rays from concrete floors and walls. (A. B. Chilton)

I269-5D024 Psychology 390. Item Analysis of Test Data for Psychology 390. The students in Psychology 390 will construct and administer a test as their laboratory exercise in the course. Item analysis and multiple regression will be used to assess the value of the test and to aid in the validation process. (Patricia Smith)

I270-5D027 Agricultural Economics 441. Problem Number 1. Agricultural Statistics Agricultural Economics 441. Students in Agricultural Economics 441 are required to complete a term report. For most of them this report involves regression or variance analysis on moderate sized sets of data. Thus the routines of SSUPAC are ordinarily used. A smaller number may use variance analysis or linear programming routines. (V. I. West)

8.3 Blanket Class Problem Specifications

During the last quarter of 1965, 32 problem specifications were submitted to cover all assigned problems in the following courses:

J222-5∅007 Nuclear Engineering 490.

J223-5∅008 Mechanical Engineering 221.

J226-5∅014 Physics 303.

J227-5∅015 Mechanical Engineering 257.

J228-5∅016 Mechanical Engineering 445.

J229-5∅017 Mechanical Engineering 256.

J230-5∅018 Mechanical Engineering 271.

J234-5∅032 Theoretical and Applied Mechanics 431.

J239-5∅048 Mechanical Engineering 409.

J240-5∅053 Mechanical Engineering 342.

J241-5∅054 General Engineering 288.

J242-5∅055 Mechanical Engineering 341.

J243-5∅056 Aeronautical and Astronautical Engineering 434.

J244-5∅065 Graduate School of Business Administration 532.

J245-5∅066 Graduate School of Business Administration 573.

J246-5∅067 Mechanical Engineering 995.

J247-5Ø068 Aeronautical and Astronautical Engineering 264.

J248-5Ø069 Electrical Engineering 296.

J249-5Ø074 Electrical Engineering 343.

J250-5Ø085 Industrial Administration 373.

J251-5Ø086 Department of Computer Science 999.

J253-5Ø088 Graduate School of Business Administration 544.

J254-5Ø090 Industrial Administration 373.

J255-5N004 Electrical Engineering 251

J257-5N012 Aeronautical and Astronautical Engineering 232.

J260-5N024 Theoretical and Applied Mechanics 311.

J261-5N027 Industrial Engineering 386.

J262-5N028 Agricultural Engineering 357.

J265-5N050 Aeronautical and Astronautical Engineering 261.

J266-5N051 Aeronautical and Astronautical Engineering 451.

J267-5D016 Finance 454.

J271-5D045 Advertising 482.

9. GENERAL LABORATORY INFORMATION

9.1 Personnel

The number of people associated with the Laboratory in various capacities is given in the following table:

	Full-time	Part-time	Full-time Equivalent
Faculty	15	1	15.5
Visiting Faculty	3	2	4.0
Graduate Research Assistants	8	58	37.25
Graduate Teaching Assistants	0	1	.5
Professional Personnel	7	2	8.5
Administrative and Clerical	17	1	17.5
Other Nonacademic Personnel	56	110	98.1
TOTAL	106	175	181.35

The Computer Advisory Committee consists of Professor J. R. Pasta, Head of the Department; Professor J. N. Snyder, Associate Head of the Department; Professors L. D. Fosdick, H. G. Friedman, C. W. Gear, D. B. Gillies, N. T. Hamilton, D. J. Kuck, B. H. McCormick, S. Muroga, T. A. Murrell, J. Nievergelt, W. J. Poppelbaum, S. R. Ray, J. E. Robertson and D. E. Slotnick.

9.2 Bibliography

During the quarter, the following publications were issued by the Laboratory.

File Numbers

[1] Amendola, R. C. "Circuit Board/Complement Illustrations for ILLIAC III," File No. 650-Add. 5, December 2, 1965.

[2] Byers, Larry L., "Operation of Core Memory I," File No. 684, November 1, 1965.

[3] Divilbiss, J. L., B. H. McCormick and K. C. Smith, "Specifications for Silicon Switching Transistors and Diodes," File No. 550-62, November 15, 1965.

[4] Gear, C. W., "An Experiment in the Use of the Proposed ILLIAC II Display Console," File No. 683, October 14, 1965.

[5] Kubitz, W. J., and D. C. Rollenhagen, "Specifications for Closed Circuit TV Camera and Monitor System," File No. 550-61, November 8, 1965.

[6] Pelg. E., K. C. Smith and J. L. Snell, "PAU Iterative Array Stalactite Testing," November 15, 1965.

File No. 660-1, "Output/Input Driver Circuit."
File No. 660-2, "Input Gate."
File No. 660-3, "M-FF."
File No. 660-4, "Input/Output Complement."
File No. 660-5, "Up/Down Select Circuit."
File No. 660-6, "True/False Circuit."
File No. 660-7, "1-8 FF "

[7] Prendergast, L. A., and K. C. Smith, "ILLIAC III Circuit Book Notes," File No. 650-183-00, Add. 1, October 25, 1965.

[8] Squires, Burton E., "A Review of the Status of Compiler-Compilers and Some Suggestions for Further Study," File No. 685, December 1, 1965.

Report Numbers

[9] Afuso, Chushin, "An Application of Intercoupled Transmission Line Amplifier," Report No. 193, November 1, 1965.

Theses

[10] Greer, M. E., "Some Investigations in the Area of High Voltage, High Current D-C Amplifiers," (M.S.), Report No. 191, October 1, 1965.

[11] Pu, Arthur T., "Generalized Decomposition of Incomplete Finite Automata," (Ph.D.), Report No. 194, December 30, 1965.

9.3 Colloquia

"Cost and Methods of Selection of Quotient Digits During Digit Division," by Professor J. E. Robertson, Research Professor of Electrical Engineering, Department of Computer Science, University of Illinois, Urbana, Illinois, October 4, 1965.

"Three Mode Factor Analysis," by Professor L. R. Tucker, Professor of Psychology, University of Illinois, Urbana, Illinois, October 11, 1965.

"An Application to Computer to Geometric Visualization," by Professor Harvey Cohn, Head, Department of Mathematics, University of Arizona, Tuscon, Arizona, October 18, 1965.

"Ambiguities in Context Free Languages," by Professor Manfred Paul, Visiting Research Associate Professor of Mathematics, Department of Computer Science, University of Illinois, Urbana, Illinois, October 25, 1965.

"An Overview of Bubble Chamber Data Analysis," by Dr. L. Kowarski, CERN, Geneva, Switzerland, November 1, 1965.

"The ILLIAC IV Project," by Professor D. E. Slotnick, Research Professor of Computer Science, Department of Computer Science, University of Illinois, Urbana, Illinois, November 15, 1965.

"Difficulties in Computing Matrix Eigenvalues and How to Overcome Them," by Mr. Beresford Parlett, Computing Center, University of California, Berkeley 4, California, November 22, 1965.

"Segmentation and the Design of Multiprogrammed Computer Systems," by Professor Jack Dennis, Associate Professor of Electrical Engineering, MIT Project MAC, Cambridge, Massachusetts, December 3, 1965.

"On the Computation Coulomb Waves Functions," by Professor Walter Gautschi, Computer Science Department, Engineering Administration Building, Purdue University, Lafayette, Indiana, December 6, 1965.

9.4 Numerical Analysis Seminar

"The Epsilon Algorithm of P. Wynn, I," by Professor D. B. Gillies, Department of Computer Science, University of Illinois, Urbana, Illinois, October 7, 1965.

"Numerical Evaluation of the Boltzmann Integral," by Mr. Richard Jenks, Coordinated Science Laboratory, University of Illinois, Urbana, Illinois, October 14, 1965.

"Band-Limited Functions - Part I," by Mr. L. K. McDowell, Department of Mathematics, University of Illinois, Urbana, Illinois, October 21, 1965.

"Band-Limited Functions - Part II," by Mr. L. K. McDowell, Department of Mathematics, University of Illinois, Urbana, Illinois, October 26, 1965.

"Eigenvalues of Large Band-Matrices," by Professor L. D. Fosdick, Department of Computer Science, University of Illinois, Urbana, Illinois, November 2, 1965.

"Parallelism in Computations," by Professor Jurg Nievergelt, Department of Computer Science, University of Illinois, Urbana, Illinois, November 9, 1965.

"The Method of Antithetic Variates in Monte Carlo," by Mr. H. F. Jordan, Department of Computer Science, University of Illinois, Urbana, Illinois, November 16, 1965.

"Numerical Procedures for Interpolation by Spline Functions," by Professor L. D. Fosdick, Department of Computer Science, University of Illinois, Urbana, Illinois, November 23, 1965.

"Numerical Procedures for Interpolation by Spline Functions, Part II," by Professor L. D. Fosdick, Department of Computer Science, University of Illinois, Urbana, Illinois, December 7, 1965.

"Numerical Problems in X-Ray Crystallography," by Professor Iain Paul, Department of Chemistry, University of Illinois, Urbana, Illinois, December 14, 1965.

"More About Spline Functions,"by Professor Don Secrest, Department of Chemistry, University of Illinois, Urbana, Illinois, December 21, 1965.

9.5 Library

The cataloguing system for the books in the Computer Science Library has been completed. Now the books are arranged according to subjects instead of authors. As mentioned before in the previous Quarterly Progress Report, the system used by Computing Reviews of the Association for Computing Machinery (ACM) was incorporated (with a few additions) for "computer" books and for the "noncomputer" books, the Library of Congress classification scheme was used.

Three professors on the Library Committee are continuing to catalogue the new books as they arrive. They work independently and then compare their decisions on which classification number to use for each book. Many books have one or two cross reference numbers in the card catalogue, but of course have only one (the original) number on the spine of the book, for shelving purposes.

The only other aspect of the library to report on is space. The amount of space remaining in the library is inversely related to the amount needed for the increasing number of books being received. It is hoped that the library in the new addition will be completed not too much later than scheduled.

9.6 Drafting

During the quarter, a total of 357 drawings were processed by both drafting sections.

	General and ILLIAC II	Pattern Recognition
Large Drawings	5	3
Medium Drawings	5	61
Small Drawings	0	4
Report Drawings (1018)	0	22
Report Drawings (Task 15)	15	0
ILLIAC II Service Reports	30	0
Layouts	0	27
ILLIAC IV	6	0
Change Orders	27	145
Semiconductor Coding Directory	0	4
Miscellaneous	3	0
TOTAL	91	266

(K. Law, L. Prendergast, S. Zundo)

9.7 Shops' Production

Job orders processed and completed during the fourth quarter of 1965, are as follows:

Facility	1018	1469	Other
Machine Shop	35	35	2
Electronics Shop	30	30	0
Etch Shop	26	22	3
Layout Shop	32	13	0

Wiring of 1,521 standard printed circuit boards during this period, accounted for 62,036 diodes and 12,668 transistors.

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